

# Technical Memorandum

**To:** Brad Wright, PE, Michelle Klose, PE

**Cc:** Mel Bullinger, PE  
Terry Halstengard  
Linda Oster, PE

**From:** Jeffrey Hruby, PE, Jonathan Lefers, PE (AE2S)

**Re:** **Tyler Coulee Stormwater Master Plan Alternative**

**Date:** April 19, 2016

This document was originally issued and sealed by:

Jeffrey M. Hruby, PE  
Registration Number PE-5403

and

Jonathan D. Lefers, PE  
Registration Number PE-7830

on

April 19, 2016

and the original documents are stored at the office of Advanced Engineering and Environmental Services, Inc.

## Recommendation

We recommend that the City adopt the modified Tyler Coulee Stormwater Master Plan (TCSWMP) displayed in *Figure 1* and described in further detail in the attached February 19, 2015 memorandum.

## Background

1. The current TCSWMP, completed in 2007, requires constructing two State-permitted High Hazard Dams at the Valley Drive and Tyler Parkway road crossings;
2. The State Water Commission prohibits water and sanitary utilities being placed in any dam embankments;
3. The City retained AE2S in October 2014 to re-evaluate the regional stormwater management options, specifically with the goal of eliminating the high hazard dams from the TCSWMP.
4. AE2S prepared a modified TCSWMP that meets the City's stormwater management criteria and eliminates the need for the two High Hazard Dams (*Figure 1* and attached memorandum);
5. AE2S and City staff met with State Water Commission, and the State Water Commission agreed that the modified plan would eliminate State-permitted regulatory dams and noted that the modified plan was a significant improvement to reducing risk associated with storage upstream of embankments;
6. The modified TCSWMP would allow the City to install utilities along Valley Drive and Tyler Parkway to serve expanding development to the north and west of Tyler Coulee, avoiding the need to gain additional easements outside of the road right-of-way;
7. AE2S prepared an opinion of probable cost for the modified TCSWMP improvements (*Table 1* and attached detailed OPC estimates for each facility); and
8. Because the proposed Valley Drive and Tyler Parkway embankments are now road culverts in the modified TCSWMP versus High Hazard Dams in the current TCSWMP, based on City policy, the City's costs for these roadways would be the pipe and a small amount of fill over the pipe versus paying for the entire dam embankment that would have been necessary with the current TCSWMP.

## Technical Memorandum

### Re: Tyler Coulee Stormwater Master Plan Alternative

April 19, 2016

#### Modified TCSWMP Summary

The following proposed detention and conveyance facilities would be removed from the plan:

- Valley Drive High Hazard Dam and outlet works, including a 25-foot high embankment, 48-inch RCP low-flow outlet structure, 25-foot high 20'x16' cast-in-place box riser structure, and 220 feet of 12'x8' outlet box culvert.
- Tyler Parkway High Hazard Dam and outlet works, including a 38-foot high embankment, 36-inch RCP low-flow outlet structure, 32-foot high 15'x12' cast-in-place box riser structure, and 250 feet of 8'x6' box outlet culvert.
- Three regional detention ponds (shown as Branch Storage Southwest, West, and East in *Figure 1*).

The following proposed detention facilities would need to be constructed:

- One new detention facility upstream of Clairmont Drive;
- One new detention facility upstream of Valley Drive;
- One new detention facility upstream of Tyler Parkway;
- One new detention facility immediately downstream of the Eagle Crest Subdivision (this facility was outlined in the current TCSWMP but has not been constructed yet); and
- Developer-constructed water quality treatment facilities to meet the City's MS4 permit for the areas draining to the previously-proposed, regional Branch Storage West, Southwest, and East facilities shown in *Figure 1*.

Conveyance improvements that are needed are as follows:

- Additional 54" culvert under Clairmont Drive to increase conveyance capacity;
- Single 84" culvert under Valley Drive embankment;
- Single 96" culvert under the future Tyler Parkway embankment;
- Additional 6'x6' box culvert under River Road; and
- Grading and channel improvements through Pioneer Park.

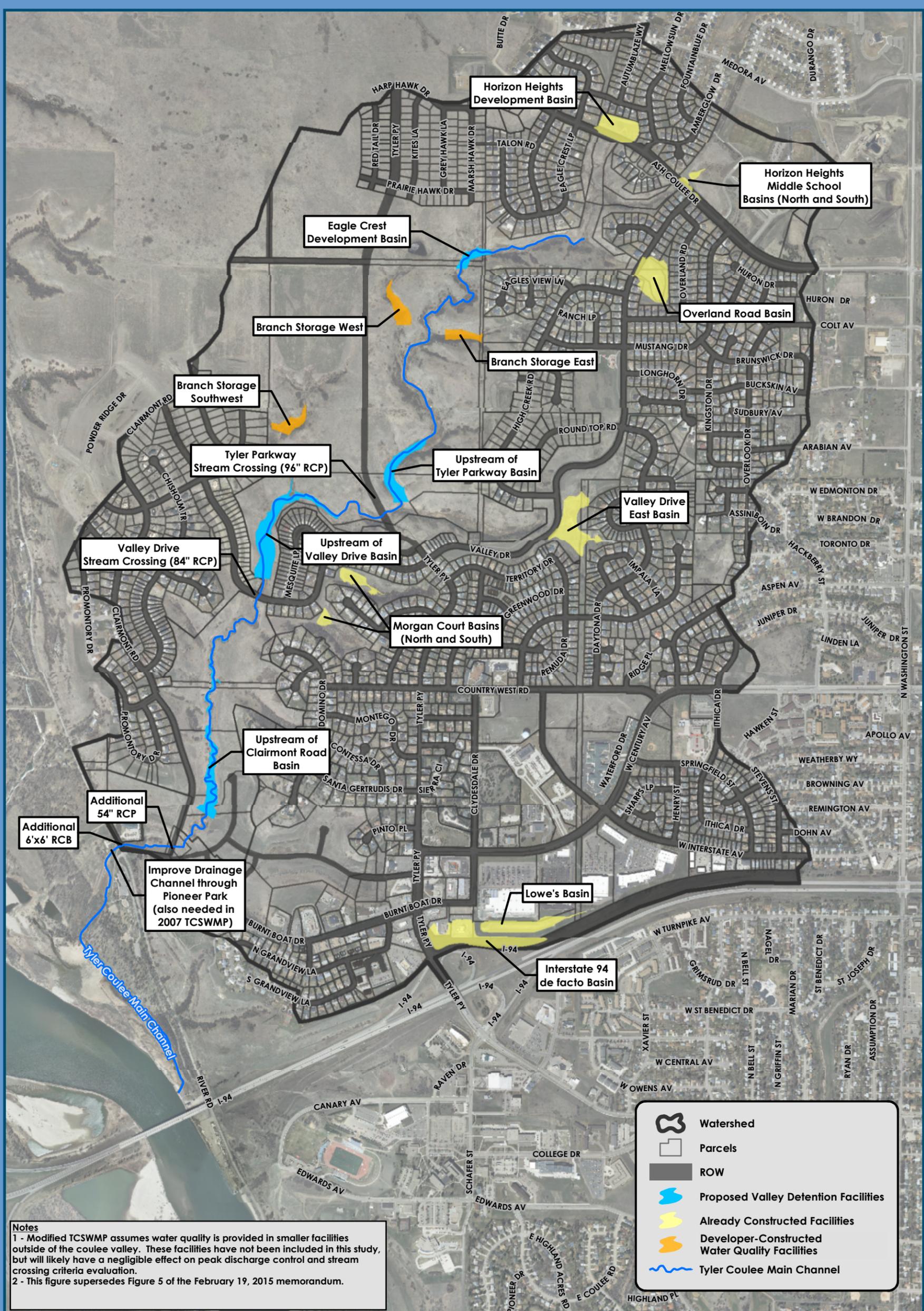
*Table 1* summarizes the costs for these improvements, noting that the water quality treatment facilities have not been included in these costs, as they are intended to be designed and constructed by the individual developments and not as regional facilities.

**Table 1:** Modified TCSWMP – Improvement Costs

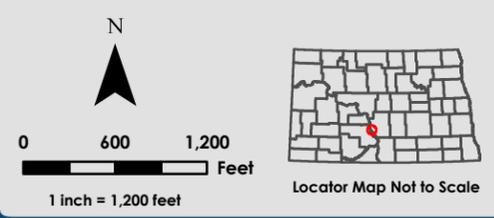
Coulee and Facility Name	Facility Type	Opinion of Probable Cost <sup>1</sup>
Clairmont Drive - Upstream Detention	Regional Detention	\$656,700
Clairmont Drive - Additional Culvert	Road Crossing	\$573,185
Valley Drive - Upstream Detention	Regional Detention	\$612,600
Valley Drive - New Culvert	Road Crossing	\$549,695
Tyler Parkway - Upstream Detention	Regional Detention	\$522,750
Tyler Parkway - New Culvert	Road Crossing	\$776,910
Eagle Crest - Detention	Regional Detention	\$386,100
River Road - Additional Culvert	Road Crossing	\$162,255
Pioneer Park - Channel Grading	Conveyance	\$153,265
Grand Total		\$4,393,460 <sup>2</sup>

<sup>1</sup> Does not include land acquisition or easement costs.

<sup>2</sup> Does not include on-site or regional water quality facility costs.



Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

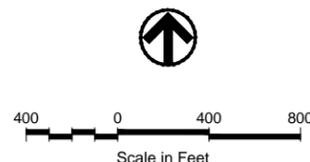
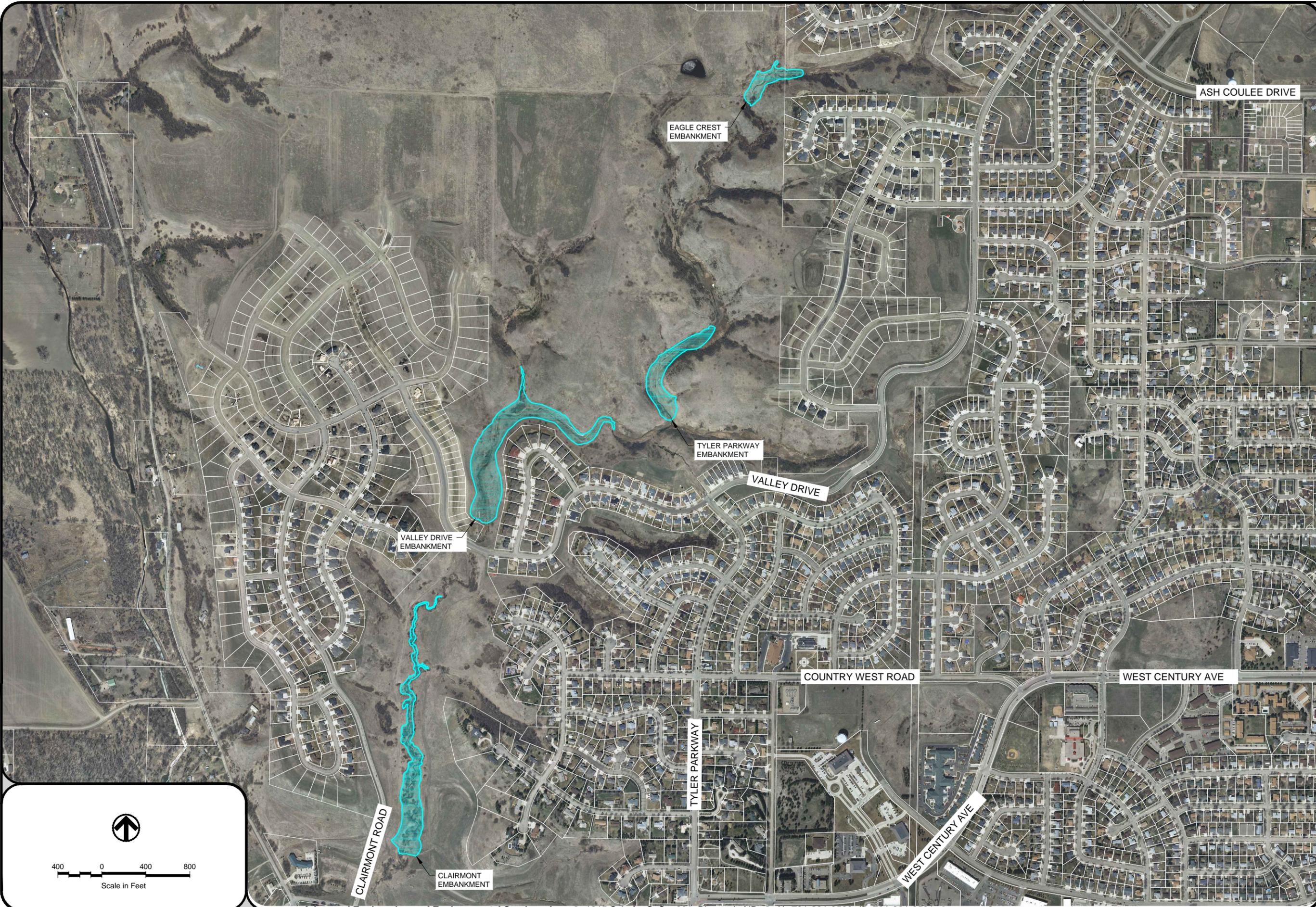


**Figure 1**  
**Modified TCSWMP Improvements**  
**Tyler Coulee Stormwater Master Plan Revision**  
**City of Bismarck | Burleigh County, ND**



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DATE	REVISION	APPROVED



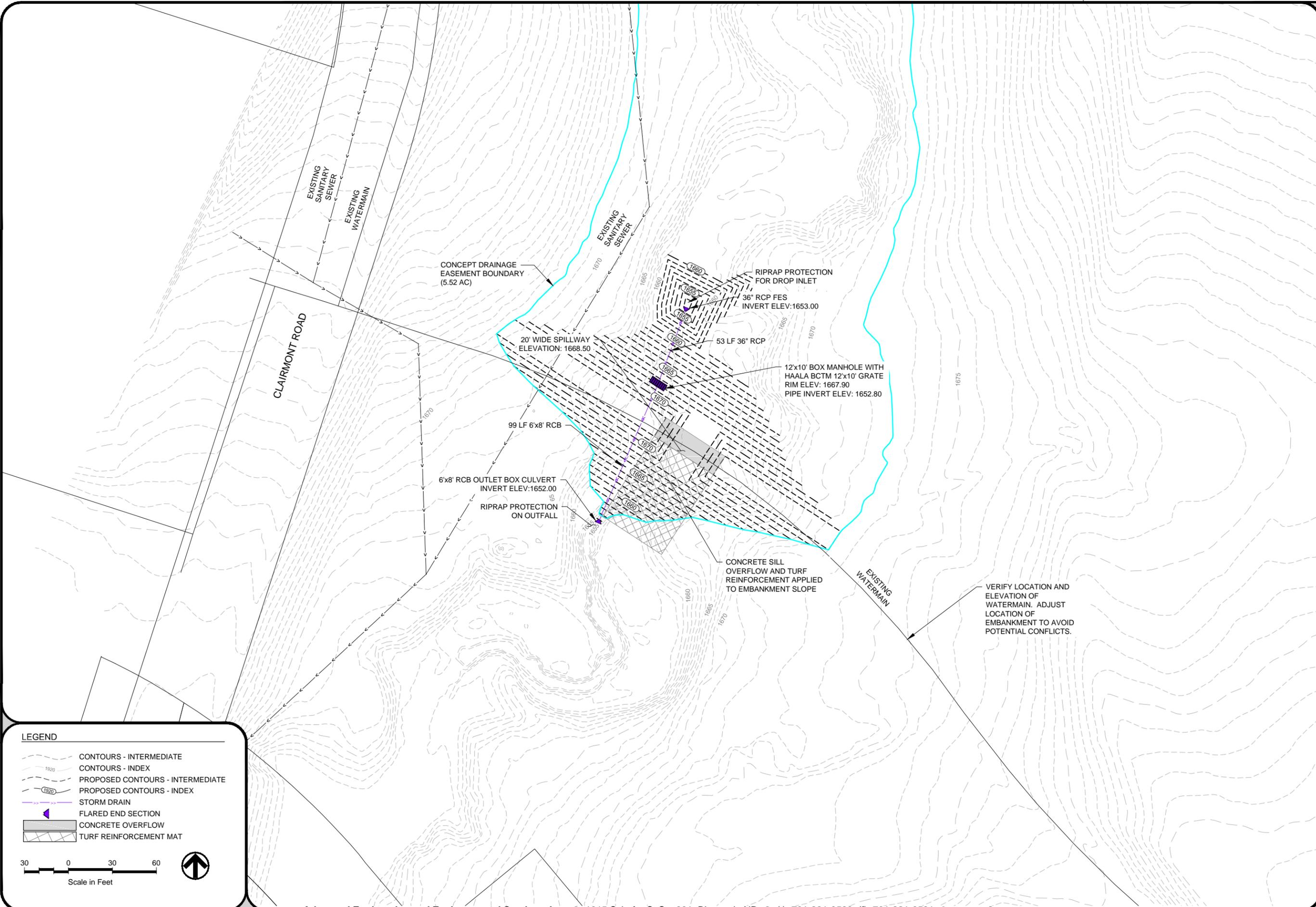
TYLER COULEE STORM WATER MASTER PLAN  
 CITY OF BISMARCK  
 CITY OF BISMARCK, BURLEIGH COUNTY NORTH DAKOTA



DRAWING TYPE	FIGURE
PREPARED BY	JG
CHECKED / APPROVED	JL / JH
DATE	NOV 2015
PROJECT NUMBER	P00501-2014-11
SHEET	1 of 5

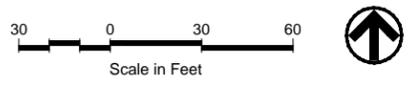
CO

OVERALL SITE MAP



**LEGEND**

	CONTOURS - INTERMEDIATE
	CONTOURS - INDEX
	PROPOSED CONTOURS - INTERMEDIATE
	PROPOSED CONTOURS - INDEX
	STORM DRAIN
	FLARED END SECTION
	CONCRETE OVERFLOW
	TURF REINFORCEMENT MAT



DATE	REVISION



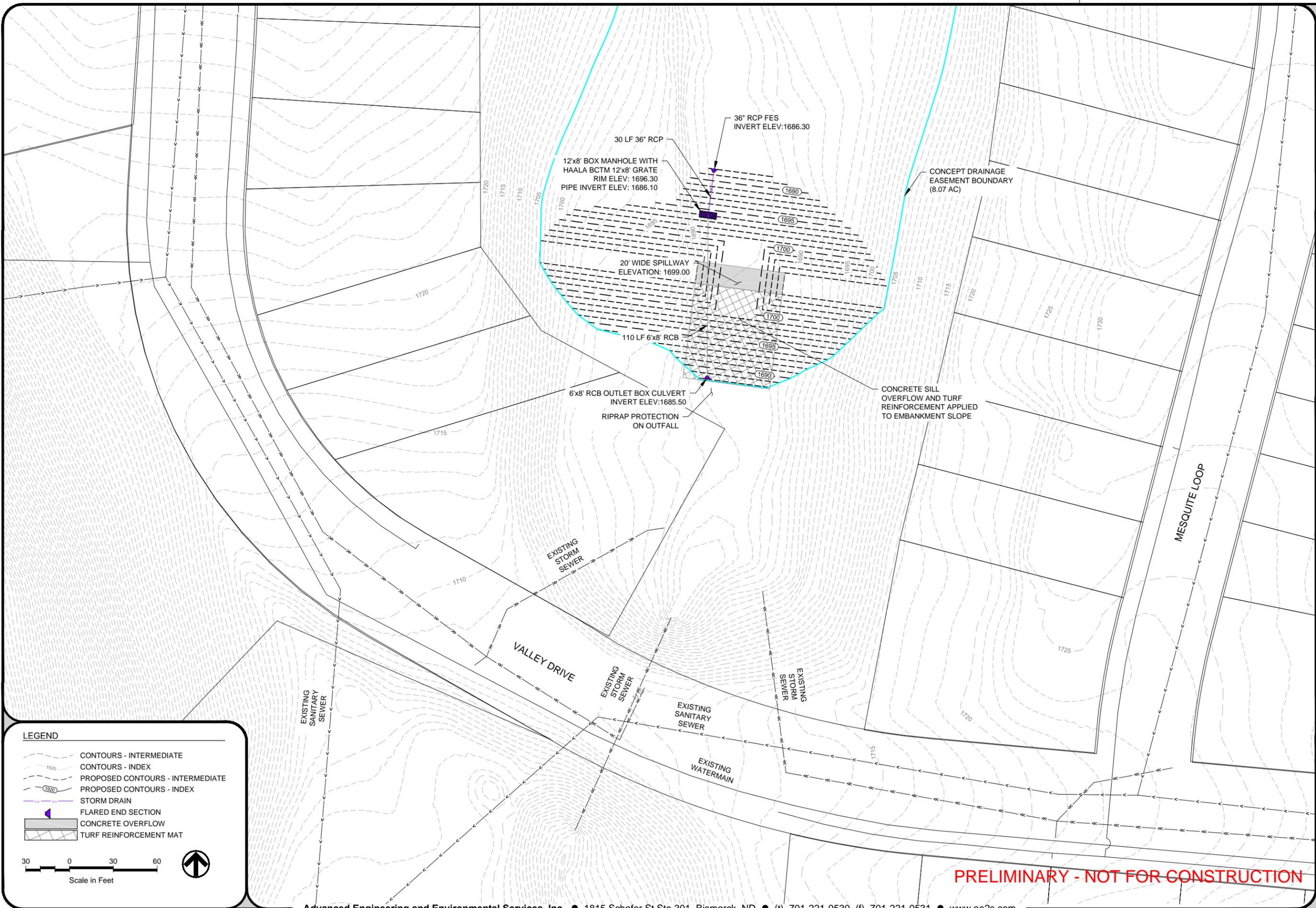
TYLER COULEE STORM WATER MASTER PLAN  
 CITY OF BISMARCK  
 CITY OF BISMARCK, BURLEIGH COUNTY NORTH DAKOTA  
 CLAIRMONT EMBANKMENT

DRAWING TYPE FIGURE
PREPARED BY JG
CHECKED / APPROVED JL / JH
DATE NOV 2015
PROJECT NUMBER P00501-2014-11
SHEET 2 of 5

**C1**

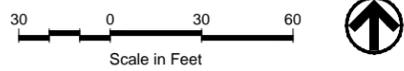
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**LEGEND**

	CONTOURS - INTERMEDIATE
	CONTOURS - INDEX
	PROPOSED CONTOURS - INTERMEDIATE
	PROPOSED CONTOURS - INDEX
	STORM DRAIN
	FLARED END SECTION
	CONCRETE OVERFLOW
	TURF REINFORCEMENT MAT



**PRELIMINARY - NOT FOR CONSTRUCTION**

APPROVED	REVISION	DATE

**TYLER COULEE STORM WATER MASTER PLAN**  
 CITY OF BISMARCK  
 CITY OF BISMARCK, BURLEIGH COUNTY NORTH DAKOTA  
 VALLEY DRIVE EMBANKMENT

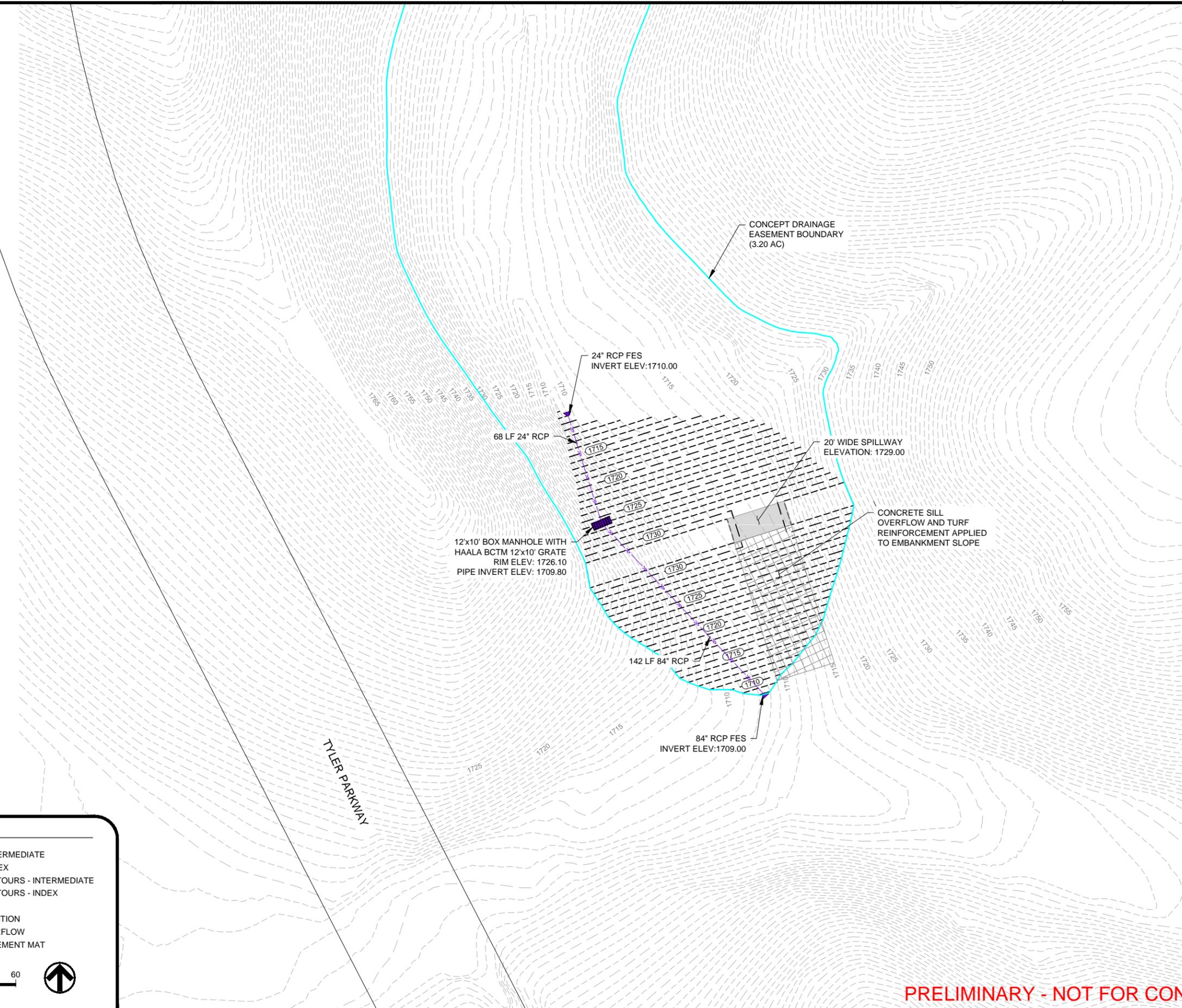
DRAWING TYPE	FIGURE
PREPARED BY	JG
CHECKED / APPROVED	JL / JH
DATE	NOV 2015
PROJECT NUMBER	P00501-2014-11
SHEET	3 of 5

**C2**

**LEGEND**

- CONTOURS - INTERMEDIATE
- CONTOURS - INDEX
- PROPOSED CONTOURS - INTERMEDIATE
- PROPOSED CONTOURS - INDEX
- STORM DRAIN
- FLARED END SECTION
- CONCRETE OVERFLOW
- TURF REINFORCEMENT MAT

Scale in Feet



**PRELIMINARY - NOT FOR CONSTRUCTION**

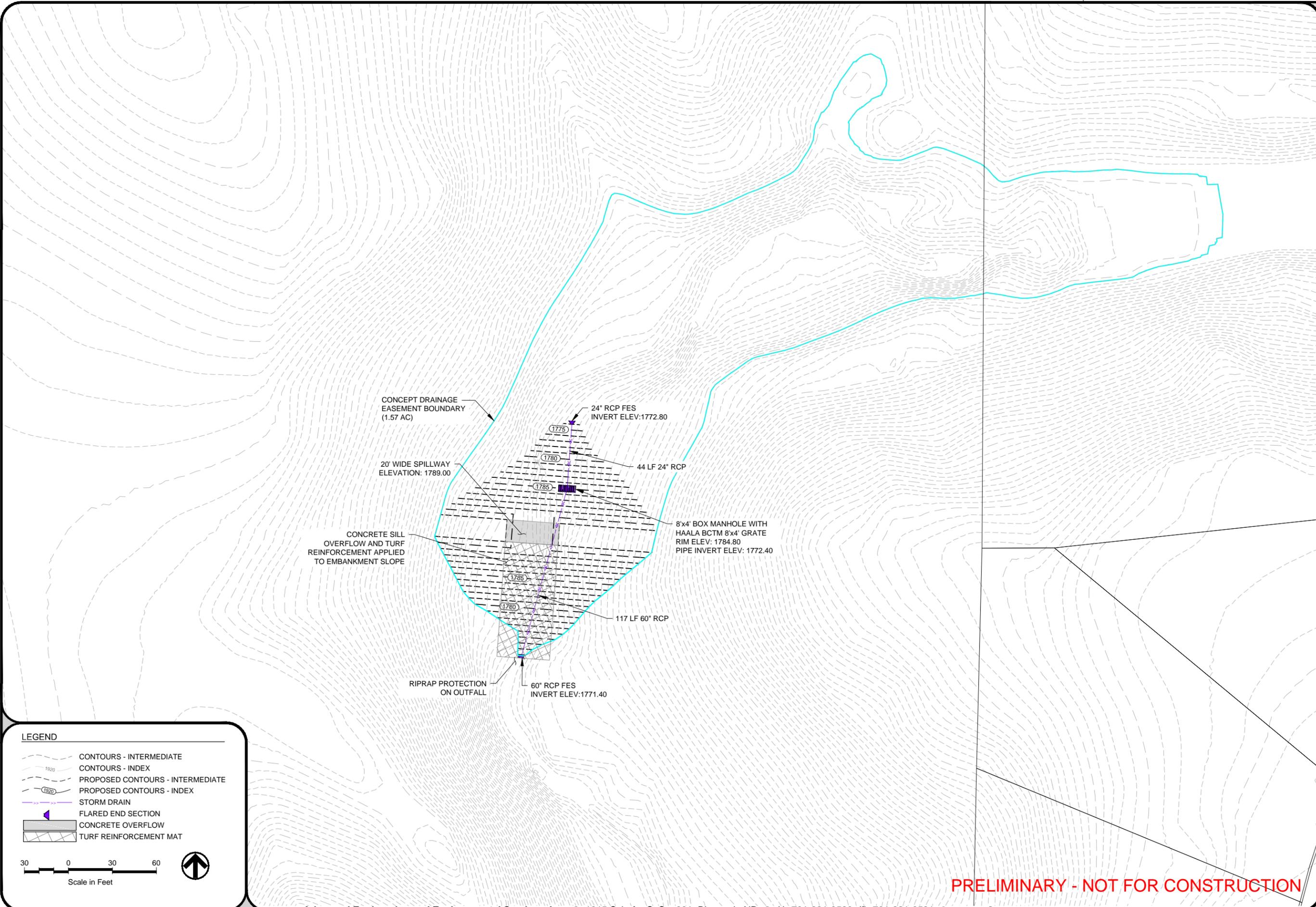
DATE	REVISION	APPROVED



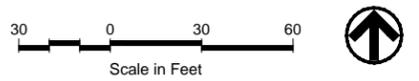
TYLER COULEE STORM WATER MASTER PLAN  
 CITY OF BISMARCK  
 CITY OF BISMARCK, BURLEIGH COUNTY NORTH DAKOTA  
 TYLER PARKWAY EMBANKMENT

DRAWING TYPE FIGURE
PREPARED BY JG
CHECKED / APPROVED JL / JH
DATE NOV 2015
PROJECT NUMBER P00501-2014-11
SHEET 4 of 5

**C3**



- LEGEND**
- CONTOURS - INTERMEDIATE
  - CONTOURS - INDEX
  - PROPOSED CONTOURS - INTERMEDIATE
  - PROPOSED CONTOURS - INDEX
  - STORM DRAIN
  - FLARED END SECTION
  - CONCRETE OVERFLOW
  - TURF REINFORCEMENT MAT



**PRELIMINARY - NOT FOR CONSTRUCTION**

APPROVED					
REVISION					
DATE					

**TYLER COULEE STORM WATER MASTER PLAN**  
 CITY OF BISMARCK  
 CITY OF BISMARCK, BURLEIGH COUNTY NORTH DAKOTA  
 EAGLE CREST EMBANKMENT

DRAWING TYPE FIGURE
PREPARED BY JG
CHECKED / APPROVED JL / JH
DATE NOV 2015
PROJECT NUMBER P00501-2014-11
SHEET 5 of 5

C4



## Engineers Opinion of Probable Costs

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$4,400	\$4,400
2	Mobilization	1	LS	\$20,700	\$20,700
3	Erosion Control	1	LS	\$19,700	\$19,700
4	5' Subcut	2,270	CY	\$9	\$20,500
5	Dispose of Unclassified Excavation	2,270	CY	\$7	\$15,900
6	Embankment Fill	6,380	CY	\$9	\$57,500
7	36-inch RCP Low-Flow Outlet Pipe	36	LF	\$140	\$5,100
8	36-inch FES	1	EA	\$1,700	\$1,700
9	6'x8' RCB Outlet Pipe	99	LF	\$750	\$74,300
10	6'x8' RCB Type 1 Sloped End Section (6')	1	EA	\$7,000	\$7,000
11	12'x10' Box Manhole (16' height), Pre-Cast Base and Custom Bar Grate	1	LS	\$37,100	\$37,100
12	HAALA BCTM12x10 Bar Grate	1	EA	\$12,000	\$12,000
13	Type VH Riprap	620	TON	\$100	\$62,000
14	Strip, Stockpile, and Replace Topsoil	465	CY	\$9	\$4,200
9	Seeding - Class VI	2,785	SY	\$1.5	\$4,200
10	Concrete Sill	1	LS	\$36,000	\$36,000
11	Erosion Control Mat	2,785	SY	\$3	\$8,400
12	Turf Reinforcement Mat	345	SY	\$6	\$2,100
13	Access Road	1	LS	\$20,000	\$20,000
14	Mitigation	1	LS	\$25,000	\$25,000

**Subtotal Construction Costs \$437,800**

**15% Contingencies \$65,670**

**Section 404 Permitting (5%) \$21,890**

**Legal, Administration & Engineering (30%) \$131,340**

**TOTAL PROJECT COSTS \$656,700**

15	Property Acquisition	5.5	Acre	\$0	\$0
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**TOTAL FACILITY COSTS \$656,700**



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$4,100	\$4,100
2	Mobilization	1	LS	\$19,300	\$19,300
3	Erosion Control	1	LS	\$18,400	\$18,400
4	5' Subcut	2,050	CY	\$9	\$18,500
5	Dispose of Unclassified Excavation	2,050	CY	\$7	\$14,400
6	Embankment Fill	7,800	CY	\$9	\$70,200
7	36-inch RCP Low-Flow Outlet Pipe	30	LF	\$140	\$4,200
8	36-inch FES	1	EA	\$1,700	\$1,700
9	6'x8' RCB Outlet Pipe	110	LF	\$750	\$82,500
10	6'x8' RCB Type 1 Sloped End Section (6')	1	EA	\$7,000	\$7,000
11	12'x8' Box Manhole (11' height), Pre-Cast Base and Custom Bar Grate	1	LS	\$25,700	\$25,700
12	HAALA BCTM12x8 Bar Grate	1	EA	\$11,000	\$11,000
13	Type VH Riprap	310	TON	\$100	\$31,000
14	Strip, Stockpile, and Replace Topsoil	460	CY	\$9	\$4,200
9	Seeding - Class VI	2,740	SY	\$1.5	\$4,200
10	Concrete Sill	1	LS	\$36,000	\$36,000
11	Erosion Control Mat	2,740	SY	\$3	\$8,300
12	Turf Reinforcement Mat	435	SY	\$6	\$2,700
13	Access Road	1	LS	\$20,000	\$20,000
14	Mitigation	1	LS	\$25,000	\$25,000
				<b>Subtotal Construction Costs</b>	<b>\$408,400</b>
				<b>15% Contingencies</b>	<b>\$61,260</b>
				<b>Section 404 Permitting (5%)</b>	<b>\$20,420</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$122,520</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$612,600</b>
15	Property Acquisition	8.1	Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$612,600</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$3,500	\$3,500
2	Mobilization	1	LS	\$16,500	\$16,500
3	Erosion Control	1	LS	\$15,700	\$15,700
4	5' Subcut	1,200	CY	\$9	\$10,800
5	Dispose of Unclassified Excavation	1,200	CY	\$7	\$8,400
6	Embankment Fill	4,575	CY	\$9	\$41,200
7	24-inch RCP Low-Flow Outlet Pipe	68	LF	\$80	\$5,500
8	24-inch FES	1	EA	\$1,100	\$1,100
9	84-inch RCP Outlet Pipe	142	LF	\$480	\$68,200
10	84-inch FES	1	EA	\$5,500	\$5,500
11	12'x10' Box Manhole (18' height), Pre-Cast Base and Custom Bar Grate	1	LS	\$40,300	\$40,300
12	HAALA BCTM12x10 Bar Grate	1	EA	\$12,000	\$12,000
13	Type VH Riprap	200	TON	\$100	\$20,000
14	Strip, Stockpile, and Replace Topsoil	460	CY	\$9	\$4,200
9	Seeding - Class VI	2,735	SY	\$1.5	\$4,200
10	Concrete Sill	1	LS	\$36,000	\$36,000
11	Erosion Control Mat	2,735	SY	\$3	\$8,300
12	Turf Reinforcement Mat	350	SY	\$6	\$2,100
13	Access Road	1	LS	\$20,000	\$20,000
14	Mitigation	1	LS	\$25,000	\$25,000
				<b>Subtotal Construction Costs</b>	<b>\$348,500</b>
				<b>15% Contingencies</b>	<b>\$52,275</b>
				<b>Section 404 Permitting (5%)</b>	<b>\$17,425</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$104,550</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$522,750</b>
15	Property Acquisition	3.2	Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$522,750</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$2,600	\$2,600
2	Mobilization	1	LS	\$12,200	\$12,200
3	Erosion Control	1	LS	\$11,600	\$11,600
4	5' Subcut	650	CY	\$9	\$5,900
5	Dispose of Unclassified Excavation	650	CY	\$7	\$4,600
6	Embankment Fill	5,230	CY	\$9	\$47,100
7	24-inch RCP Low-Flow Outlet Pipe	44	LF	\$80	\$3,600
8	24-inch FES	1	EA	\$1,100	\$1,100
9	60-inch RCP Outlet Pipe	117	LF	\$290	\$34,000
10	60-inch FES	1	EA	\$3,000	\$3,000
11	8'x4' Box Manhole (13.5' height), Pre-Cast Base and Custom Bar Grate	1	LS	\$16,400	\$16,400
12	HAALA BCTM8x4 Bar Grate	1	EA	\$5,000	\$5,000
13	Type VH Riprap	170	TON	\$100	\$17,000
14	Strip, Stockpile, and Replace Topsoil	285	CY	\$9	\$2,600
9	Seeding - Class VI	1,710	SY	\$1.5	\$2,600
10	Concrete Sill	1	LS	\$36,000	\$36,000
11	Erosion Control Mat	1,710	SY	\$3	\$5,200
12	Turf Reinforcement Mat	315	SY	\$6	\$1,900
13	Access Road	1	LS	\$20,000	\$20,000
14	Mitigation	1	LS	\$25,000	\$25,000
				<b>Subtotal Construction Costs</b>	<b>\$257,400</b>
				<b>15% Contingencies</b>	<b>\$38,610</b>
				<b>Section 404 Permitting (5%)</b>	<b>\$12,870</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$77,220</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$386,100</b>
15	Property Acquisition	1.6	Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$386,100</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$4,000	\$4,000
2	Mobilization	1	LS	\$18,700	\$18,700
3	Erosion Control	1	LS	\$17,800	\$17,800
4	Pipe Compacted Backfill	0	CY	\$10	\$0
5	Strip, Stockpile, and Replace Topsoil	0	CY	\$9	\$0
6	Seed and Mulch	0	SY	\$2	\$0
7	54-inch Steel Pipe (Bore and Jack)	304	LF	\$1,100	\$334,400
8	54-inch FES	2	EA	\$2,700	\$5,400
9	Type VH Riprap	150	TON	\$100	\$15,000
				<b>Subtotal Construction Costs</b>	<b>\$395,300</b>
				<b>15% Contingencies</b>	<b>\$59,295</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$118,590</b>
9				<b>TOTAL PROJECT COSTS</b>	<b>\$573,185</b>
10	Property Acquisition		Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$573,185</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$3,800	\$3,800
2	Mobilization	1	LS	\$17,900	\$17,900
3	Erosion Control	1	LS	\$17,100	\$17,100
4	Pipe Compacted Backfill	3,140	CY	\$10	\$29,900
5	Strip, Stockpile, and Replace Topsoil	350	CY	\$9	\$3,200
6	Seed and Mulch	2,100	SY	\$2	\$4,200
7	84-inch RCP	272	LF	\$1,000	\$272,000
8	84-inch FES	2	EA	\$5,500	\$11,000
9	Type VH Riprap	200	TON	\$100	\$20,000
				<b>Subtotal Construction Costs</b>	<b>\$379,100</b>
				<b>15% Contingencies</b>	<b>\$56,865</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$113,730</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$549,695</b>
9					
10	Property Acquisition		Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$549,695</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$5,400	\$5,400
2	Mobilization	1	LS	\$25,300	\$25,300
3	Erosion Control	1	LS	\$24,100	\$24,100
4	Pipe Compacted Backfill	4,100	CY	\$10	\$39,000
5	Strip, Stockpile, and Replace Topsoil	600	CY	\$9	\$5,400
6	Seed and Mulch	2,900	SY	\$2	\$5,800
7	96-inch RCP	329	LF	\$1,200	\$394,800
8	96-inch FES	2	EA	\$6,500	\$13,000
9	Type VH Riprap	230	TON	\$100	\$23,000
				<b>Subtotal Construction Costs</b>	<b>\$535,800</b>
				<b>15% Contingencies</b>	<b>\$80,370</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$160,740</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$776,910</b>
9					
10	Property Acquisition		Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$776,910</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$1,200	\$1,200
2	Mobilization	1	LS	\$5,300	\$5,300
3	Erosion Control	1	LS	\$5,100	\$5,100
4	Mill Existing Pavement	80	SY	\$6	\$500
5	1' Gravel Subbase	80	SY	\$20	\$1,600
6	4" Asphalt Hotmix	80	SY	\$28	\$2,300
7	Pipe Compacted Backfill	1,000	CY	\$10	\$9,500
8	Miscellaneous Grading	1,000	CY	\$10	\$10,000
9	Seeding - Class VI	300	SY	\$1.5	\$500
10	Erosion Control Mat	300	SY	\$3	\$900
11	6'x6' RCB Outlet Pipe	60	LF	\$700	\$42,000
12	6'x6' RCB Type 1 Sloped End Section (6')	2	EA	\$6,500	\$13,000
13	Type VH Riprap	200	TON	\$100	\$20,000
				<b>Subtotal Construction Costs</b>	<b>\$111,900</b>
				<b>15% Contingencies</b>	<b>\$16,785</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$33,570</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$162,255</b>
14	Property Acquisition		Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$162,255</b>



**Engineers Opinion of Probable Costs**

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	\$1,100	\$1,100
2	Mobilization	1	LS	\$5,000	\$5,000
3	Erosion Control	1	LS	\$4,800	\$4,800
4	Clearing and Grubbing	1	LS	\$30,000	\$30,000
5	Excavate and Replace On Site (4' Deep, 50' Bottom Width, 4H:1V Side Slopes)	2,500	SY	\$10	\$23,800
6	Seeding - Class VI	13,000	SY	\$1.5	\$19,500
7	Erosion Control Mat	6,000	SY	\$3	\$18,000
8	Mulch	7,000	LF	\$0.5	\$3,500

				<b>Subtotal Construction Costs</b>	<b>\$105,700</b>
				<b>15% Contingencies</b>	<b>\$15,855</b>
				<b>Legal, Administration &amp; Engineering (30%)</b>	<b>\$31,710</b>
				<b>TOTAL PROJECT COSTS</b>	<b>\$153,265</b>
9	Property Acquisition		Acre	\$0	\$0
				<b>TOTAL FACILITY COSTS</b>	<b>\$153,265</b>

# Technical Memorandum

**To:** John Paczkowski, PE, CFM (ND State Water Commission)

**Cc:** Karen Goff, PE (ND State Water Commission)  
Mandar Nangare, M.S., CFM (ND State Water Commission)  
Brad Wright, PE (City of Bismarck)  
Keith Demke PE (City of Bismarck)  
Terry Halstengard (City of Bismarck)  
Linda Oster, PE (City of Bismarck)

**From:** Jeffrey Hruby PE, Jonathan Lefers PE (AE2S)

**Re:** **City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design**

**Date:** February 19, 2015

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## Purpose

The purpose of this memorandum is to document the updated analysis and conceptual design for the Valley Drive and Tyler Parkway embankments such that the crossings meet the State's stream crossing standards. In addition this analysis also includes Clairmont Road because the embankment can also store greater than 25 acre-feet and therefore must still meet stream crossing criteria with any proposed upstream changes.

## Performance Criteria

### State Dam Criteria

The State of North Dakota requires a permit for the construction of a dam for structures that meet both the criteria below:

1. Exceed 25 acre-feet of storage for a medium or high hazard dam (Chapter 61-16.1-38 of North Dakota Century Code). Discussions with State Water Commission staff have clarified the calculation of storage as measured from the natural stream invert to the lowest overflow point in the embankment.
2. The structure does not meet the minimum stream crossing capacity requirements outlined in North Dakota Century Code, Chapter 89-14-01, Sections 03 and 05. The design event for urban roadway culverts is the 25-year (24-hour) event, and the allowable headwater in Tyler Coulee (based on stream valley slope) is 2 pipe diameters. For example, a 48-inch culvert has an allowable 25-year, 24-hour maximum allowable headwater of 8 feet.

Further, based on in-person discussions with State Water Commission staff as part of this project, the State also evaluates a qualitative "intent" of the embankment on whether it would qualify as a dam. If the intent is to attenuate flow, then it can be considered a dam even if the stream crossing capacity criterion is met.

### City Stormwater Management Criteria

While the State Water Commission does not regulate stormwater management performance criteria relating to peak discharge control and water quality treatment, the City's criteria is relevant to the discussion in that it drives

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## Technical Memorandum

### Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

---

the need for storage within the watershed to control post-development flows. Below is a brief summary of the City's stormwater management criteria and how it relates to the design of storage within the Tyler Coulee watershed.

1. Provide water quality treatment to meet the City's MS4 permit:

This conceptual alternative analysis assumed that water quality treatment for new development would be provided in smaller regional facilities not located within the main Tyler Coulee valley. Since these facilities are typically small and are focused on events much smaller than the 25- or 100-year event, these types of facilities were not accounted for in the flow routing analysis.

2. Provide peak discharge control such that the 2-, 10-, and 100-year peak discharge rates existing before the proposed development shall not be increased:

Similar to other stormwater master planning efforts by the City, the point of compliance for peak discharge is based on the watershed discharge point, which in this case is at River Road. In other words, peak discharge may be increased at various points within the watershed, but the stormwater management master plan controls peak discharge such that the proposed peak does not exceed the existing peak when compared for the entire watershed.

## Data

The following data were used in this study:

- 2013 Bismarck-Mandan LiDAR data and 2-foot contours;
- 1957-1962 Historical Aerial Photograph, available from the North Dakota GIS Hub;
- Future Land Use Plan from 2014 Growth Management Plan, obtained from the City;
- Conceptual development plan for Burnt Boat Drive corridor, obtained from Bill Clairmont;
- Concept development density for NE ¼ section of Section 19, obtained from Wade Felton;
- Tyler Coulee Storm Water Assessment and Management Plan (July 2002), prepared by Houston Engineering, Inc. and obtained from the City;
- Tyler Coulee Storm Water Master Plan (TCSWMP, February 2007), prepared by Houston Engineering, Inc. and obtained from the City;
- XP-SWMM stormwater model for Alternative 4, as outlined in Appendix D of the TCSWMP and obtained from the City;
- Construction Plans for Tyler Coulee Storm Water Facilities (Valley Drive and Tyler Parkway Embankments), Sewer Improvement District No. 08-513 obtained from the City;
- Stormwater Management Plans for multiple developments throughout the watershed, obtained from the City. Primary relevant plans include:
  - Country West XXII – Overland Road basin
  - County West XXVII – Morgan Court North and South basins
  - Horizon Heights 1<sup>st</sup> Addition – Two small stormwater management facilities along Ash Coulee Drive
  - Horizon Heights 4<sup>th</sup> Addition – Updates analysis of basin north of Horizon Heights 1<sup>st</sup> Addition
  - Pinehurst – Kohl's site and routing of flow to the existing Lowe's basin.

## Technical Memorandum

### Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

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- Limited survey of key culverts (River Road, Clairmont Road, and Valley Drive) along with channel cross sections through Pioneer Park.

All elevations listed in this report are relative to NAVD88, unless noted otherwise. While the City’s standard datum for engineering design is NGVD29, the 2013 LiDAR data is in NAVD88, so the more recent datum was used in this study.

### Modeling Assumptions

#### Modeling Software

The peak discharge analysis was completed using InfoSWMM, a proprietary GIS-based version of the EPA SWMM model, which is widely accepted for urban stormwater and drainage analyses.

#### Rainfall

For the purposes of evaluating compliance with stream crossing criteria, the 24-hour rainfall depths from NOAA Atlas 14 were used (**Table 1**). As a comparison, the TP-40 rainfall depths that were originally used to size the Valley Drive and Tyler Parkway crossings are also included, which indicates that the 100-year rainfall depths are much higher with the newer Atlas 14 data. The SCS Type II distribution was used for all storms.

**Table 1:** 24-Hour Rainfall Depths for Bismarck, North Dakota

Frequency	Atlas 14 Rainfall (inches)	TP-40 Rainfall (inches)
2-year	2.1	2.0
10-Year	3.1	3.4
25-year	3.9	3.8
50-Year	4.6	4.3
100-year	5.3	4.8

### Original (2007) TCSWMP Conditions

#### Watershed Boundary

Based on the 2007 TCSWMP, 2013 LiDAR, and City storm sewer GIS database, the full build-out Tyler Coulee watershed boundary is approximately 1,870 acres in size and is shown in **Figure 1**. Hydrologic Soil Group classifications for soils within the watershed are shown in **Figure 1** as well.

#### Land Use

Based on the 2014 Growth Management Plan, development requests by private developers for undeveloped lands, 2009 aerial, and City’s parcel data, full build-out land use was estimated and is indicated on **Figure 2**, which also summarizes the assumed impervious area by land use.

#### Subwatersheds

Using the subwatershed map shown in the 2007 TCSWMP with minor modifications based on the City’s storm sewer GIS database, 2013 LiDAR, and approved private stormwater management plans, the subwatersheds were updated for this study. **Figure 3** illustrates the full build-out subwatershed boundaries and parameters. Subwatershed ID’s from the 2007 TCSWMP were preserved to the extent possible.

Times of concentration were estimated based on the following approach:

- Area less than 40 acres: 15 minutes
- Area between 40 and 80 acres: 25 minutes
- Area greater than 80 acres: 35 minutes

## Technical Memorandum

### Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

---

#### Hydraulic Geometry

Both already-constructed and future-planned facilities outlined in the 2007 TCSWMP were input into this scenario (**Figure 4**). Geometries of facilities were based on the following information:

- For already-constructed facilities, stage-area relationships were based off 2013 LiDAR. Pipe sizes and inverts were based on site survey where collected or the XP-SWMM model, adjusted for NGVD29 to NAVD88 (+1.3 feet) as the 2007 TCSWMP is referenced to NGVD29. However, it should be noted that one of the storm sewer segments in Burnt Boat Drive was input into XP-SWMM as a 42-inch storm sewer, whereas the City GIS database, as-built drawings, and the SWMM ID label indicate that it should be a 72-inch storm sewer. Therefore, the storm sewer in Burnt Boat Drive was modeled as 72-inch storm sewer.
- For future-planned facilities, the XP-SWMM model and Tyler Coulee / Valley Drive construction plans were used, converted from NGVD29 to NAVD88.

Storage upstream of Clairmont Road, Valley Drive, and Tyler Parkway were modeled via natural cross sections instead of a storage node, which is more appropriate given the riverine / valley storage nature of these facilities.

**Table 2** at the end of this memorandum summarizes the storage included in the hydraulic model either in the Tyler Coulee valley upstream of road crossings or in detention basins distributed throughout the watershed.

#### Road Crossings

##### **Clairmont Road**

**Chart 1** illustrates the stage hydrograph for the 25- and 100-year events. The 25-year event is the criterion for meeting stream crossing standards, and the 100-year event is additional information that the State Water Commission requested for consideration of the “intent” of the road embankments. The chart suggests that with the updated land use, soils, rainfall, and already-constructed improvements, Clairmont Road would meet stream crossing criteria under the original TCSWMP improvements.

**Chart 2** displays the stage-duration graph for the 2- through 100-year events. The chart indicates that for all events, ponding upstream occurs for less than 24 hours.

**Table 3** at the end of this memorandum summarizes additional hydraulic information on the Clairmont Road crossing, as requested by the State Water Commission.

##### **Valley Drive and Tyler Parkway**

As expected, Valley Drive and Tyler Parkway would be classified as regulatory dams, as they do not meet stream crossing criteria (**Charts 3 and 4**), and the storage upstream of each embankment is well above 25 acre-feet.

**Charts 5 and 6** also display the ponding conditions upstream of Valley Drive and Tyler Parkway, but as stage-duration curves and for the 2- through 100-year events. While the overall duration of ponding is still fairly short (less than 12 hours of ponding greater than 2 feet even in the 100-year event), the stage-duration curves indicate that at the higher stages, the drawdown is more gradual than at Clairmont Road, which is constructed as a stream crossing.

**Table 3** at the end of this memorandum summarizes additional hydraulic information on the Clairmont Road crossing, as requested by the State Water Commission.

## Technical Memorandum

### Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

---

## Alternative Stormwater Master Plan Conditions

### Hydraulic Geometry Changes

For the Alternative Master Plan developed as part of this project, the following changes were made to the 2007 TCSWMP (**Figure 5**):

- River Road – Added an additional 6'x6' box culvert to avoid overtopping the road in the 25-year event
- Clairmont Road – added a 54" RCP storm sewer approximately 5 feet above the channel invert / existing 84" RCP culvert so that the 84" RCP would still meet stream crossing criteria.
- New 24.9 acre-foot regional detention facility upstream of Clairmont Road (separate from Clairmont Road embankment).
- Valley Drive – Replaced proposed dam outlet works with a single 84" RCP stream crossing.
- New 24.9 acre-foot regional detention facility upstream of Valley Drive.
- Tyler Parkway – Replaced proposed dam outlet works with a single 96" RCP stream crossing.
- New 24.9 acre-foot regional detention facility upstream of Tyler Parkway. .
- While this does not have an effect on the overall performance of the system, the 2007 TCSWMP proposed valley storage facility near Eagle Crest was modified slightly so that it would provide improved water quality treatment.

### Road Crossings

#### **Clairmont Road**

**Chart 7** displays the stage hydrograph for the 25- and 100-year events (24-hour storm duration) for the Alternative plan with an additional 54" RCP added, which indicates that the proposed 84" culvert meets stream crossing criteria.

**Chart 8** is the stage-duration curve for upstream of Clairmont Road, which indicates that the drawdown to 6 feet (lower than the pipe crown of 7 feet) is rapid, as it occurs in approximately 4 hours. Comparing **Chart 8** to **Chart 2** (stage-duration curve for the original TCSWMP) illustrates that the time above the crown of the pipe is reduced with the Alternative Plan.

**Table 4** at the end of this memorandum summarizes additional hydraulic information for the Clairmont Road crossing, which illustrates that the routing effect of the road crossing is minimal for most events.

#### **Valley Drive**

**Charts 9 and 10** display the stage hydrograph and stage-duration curves, respectively, for the Valley Drive embankment and 84" RCP culvert. **Table 4** at the end of this memorandum also summarizes additional hydraulic performance parameters. Five key observations with respect to both the explicit stream crossing criteria and intent of the crossing are notable:

1. The peak 25-year headwater is less than two pipe diameters, which meets the criterion outlined in State standards for stream crossing capacity requirements.
2. The peak 100-year event is still almost 10 feet below the crest of the road, indicating that the proposed culvert does not maximize storage behind the embankment in order to route flow.
3. The 100-year event is only above the crown of the pipe for approximately 4 to 5 hours.
4. Comparing the Alternative Plan stage-duration plot (**Chart 10**) to the original TCSWMP stage-duration plot (**Chart 5**) also illustrates that the ponding duration above the pipe crown is reduced significantly for the Alternative Plan.

## Technical Memorandum

### Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

---

5. The routing effect at the crossing is negligible and much less than the original TCSWMP proposal, as the routing is now provided in the 24.9 acre-foot detention facility located upstream of Valley Drive instead of at the road crossing itself.

#### Tyler Parkway

Similar to Valley Drive, Tyler Parkway would meet stream crossing criteria with a 96” RCP (*Charts 11 and 12*). Further, the Tyler Parkway embankment and culvert also meet the intent of a stream crossing by having:

1. The peak 100-year headwater is also below the two pipe diameter threshold.
2. The peak 100-year event is over 20 feet below the crest of the road– much lower than the original TCSWMP peak headwater.
3. The 100-year stage is only above the crown of the pipe for approximately 2 hours.
4. Comparing the Alternative Plan stage-duration plot (*Chart 12*) to the original TCSWMP stage-duration plot (*Chart 6*) indicates that the ponding duration as well as peak ponding depths are significantly reduced with the Alternative Plan.
5. The routing effect at the crossing is negligible and much less than the original TCSWMP proposal, as the routing is now provided in the 24.9 acre-foot detention facility located upstream of Tyler Parkway instead of at the road crossing itself.

#### Conclusions and Recommendations

The results of this study indicate that it is feasible to eliminate the need for State-regulated dams to meet the City’s stormwater management objectives. The following proposed detention facilities would need to be constructed:

- 24.9 acre-foot facility upstream of Clairmont Drive;
- 24.9 acre-foot facility upstream of Valley Drive;
- 24.9 acre-foot facility upstream of Tyler Parkway Drive;
- 8.5 acre-foot facility immediately downstream of the Eagle Crest Subdivision; and
- Regional or on-site water quality treatment facilities to meet the City’s MS4 permit.

Conveyance improvements that are needed are as follows:

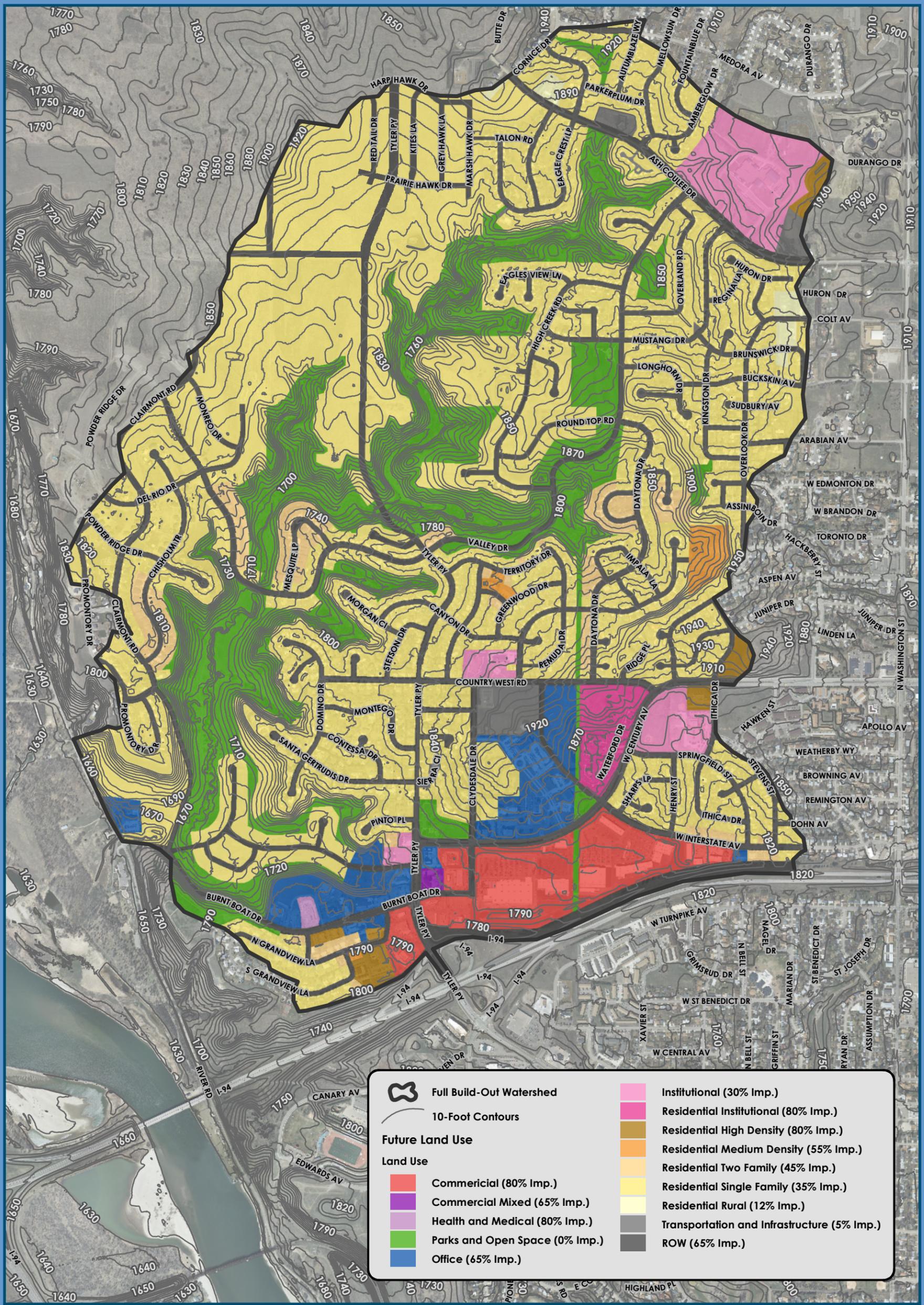
- Additional 54” culvert under Clairmont Drive that is offset from the channel invert approximately 5 feet so that the road still meets stream crossing criteria while not increasing peak discharges in smaller events;
- Single 84” culvert under Valley Drive embankment; and
- Single 96” culvert under the future Tyler Parkway embankment.

Based on the results of this analysis, we request concurrence from the State Water Commission that the proposed Tyler Parkway and Valley Drive crossings meet the definition of Stream Crossings outlined in North Dakota Century Code, Chapter 89-14-01 and will not be required to obtain a permit for construction of a dam.

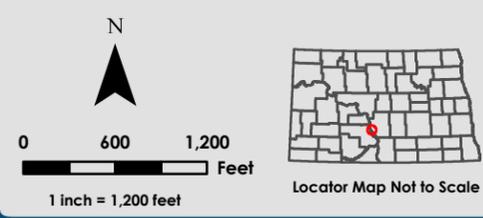
AE2S is pleased to submit this Technical Memorandum on behalf of the City of Bismarck. If you have any questions or comments, please contact Jeff Hruby at 701-221-0530 or [jeff.hruby@ae2s.com](mailto:jeff.hruby@ae2s.com).

**FIGURES**



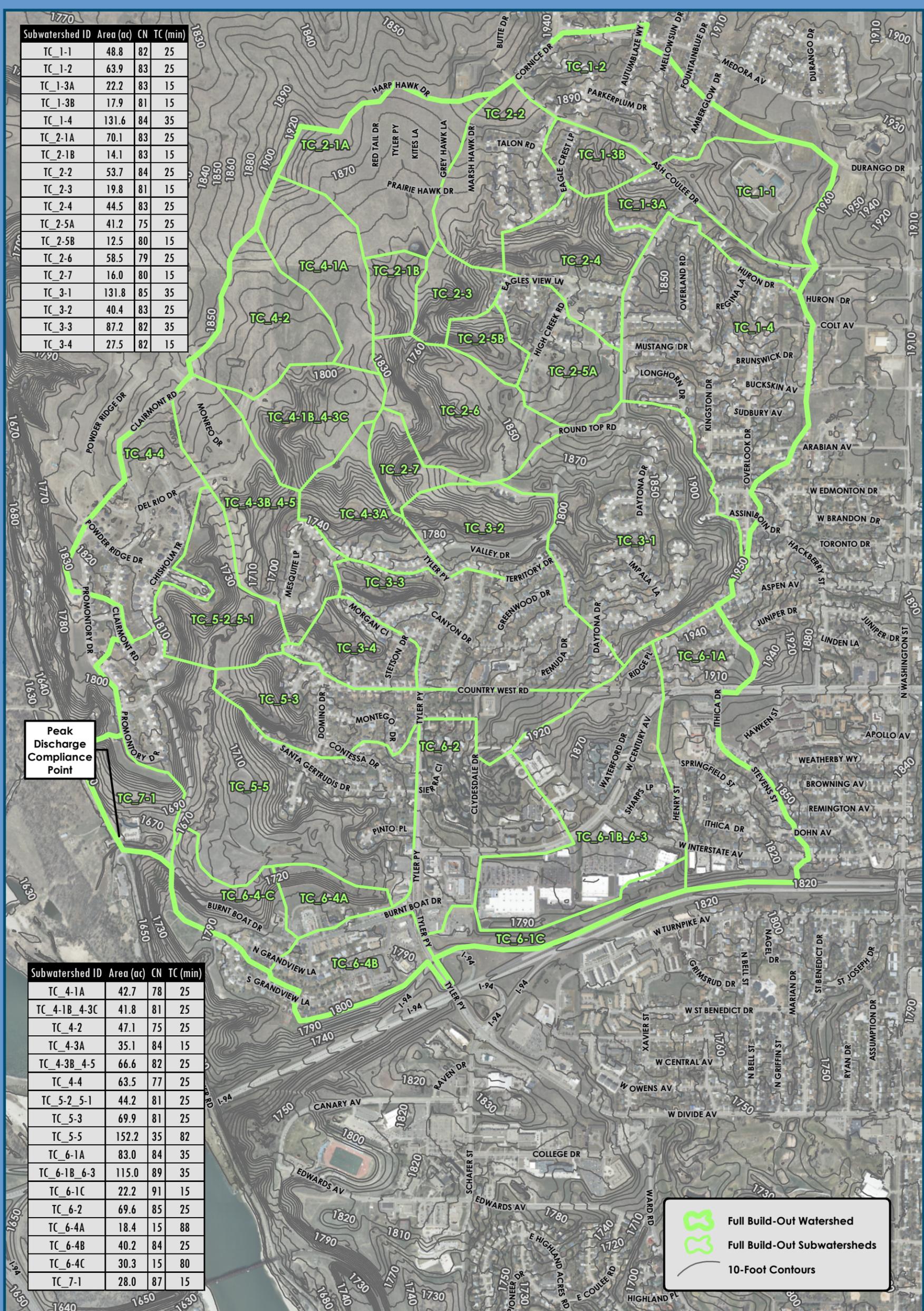


Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.



**Figure 2-**  
**Full Build-Out Land Use**  
**Tyler Coulee Stormwater Ponds**  
**City of Bismarck | Burleigh County, ND**



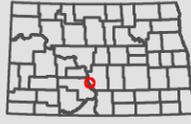


Subwatershed ID	Area (ac)	CN	TC (min)
TC_1-1	48.8	82	25
TC_1-2	63.9	83	25
TC_1-3A	22.2	83	15
TC_1-3B	17.9	81	15
TC_1-4	131.6	84	35
TC_2-1A	70.1	83	25
TC_2-1B	14.1	83	15
TC_2-2	53.7	84	25
TC_2-3	19.8	81	15
TC_2-4	44.5	83	25
TC_2-5A	41.2	75	25
TC_2-5B	12.5	80	15
TC_2-6	58.5	79	25
TC_2-7	16.0	80	15
TC_3-1	131.8	85	35
TC_3-2	40.4	83	25
TC_3-3	87.2	82	35
TC_3-4	27.5	82	15

Subwatershed ID	Area (ac)	CN	TC (min)
TC_4-1A	42.7	78	25
TC_4-1B_4-3C	41.8	81	25
TC_4-2	47.1	75	25
TC_4-3A	35.1	84	15
TC_4-3B_4-5	66.6	82	25
TC_4-4	63.5	77	25
TC_5-2_5-1	44.2	81	25
TC_5-3	69.9	81	25
TC_5-5	152.2	35	82
TC_6-1A	83.0	84	35
TC_6-1B_6-3	115.0	89	35
TC_6-1C	22.2	91	15
TC_6-2	69.6	85	25
TC_6-4A	18.4	15	88
TC_6-4B	40.2	84	25
TC_6-4C	30.3	15	80
TC_7-1	28.0	87	15

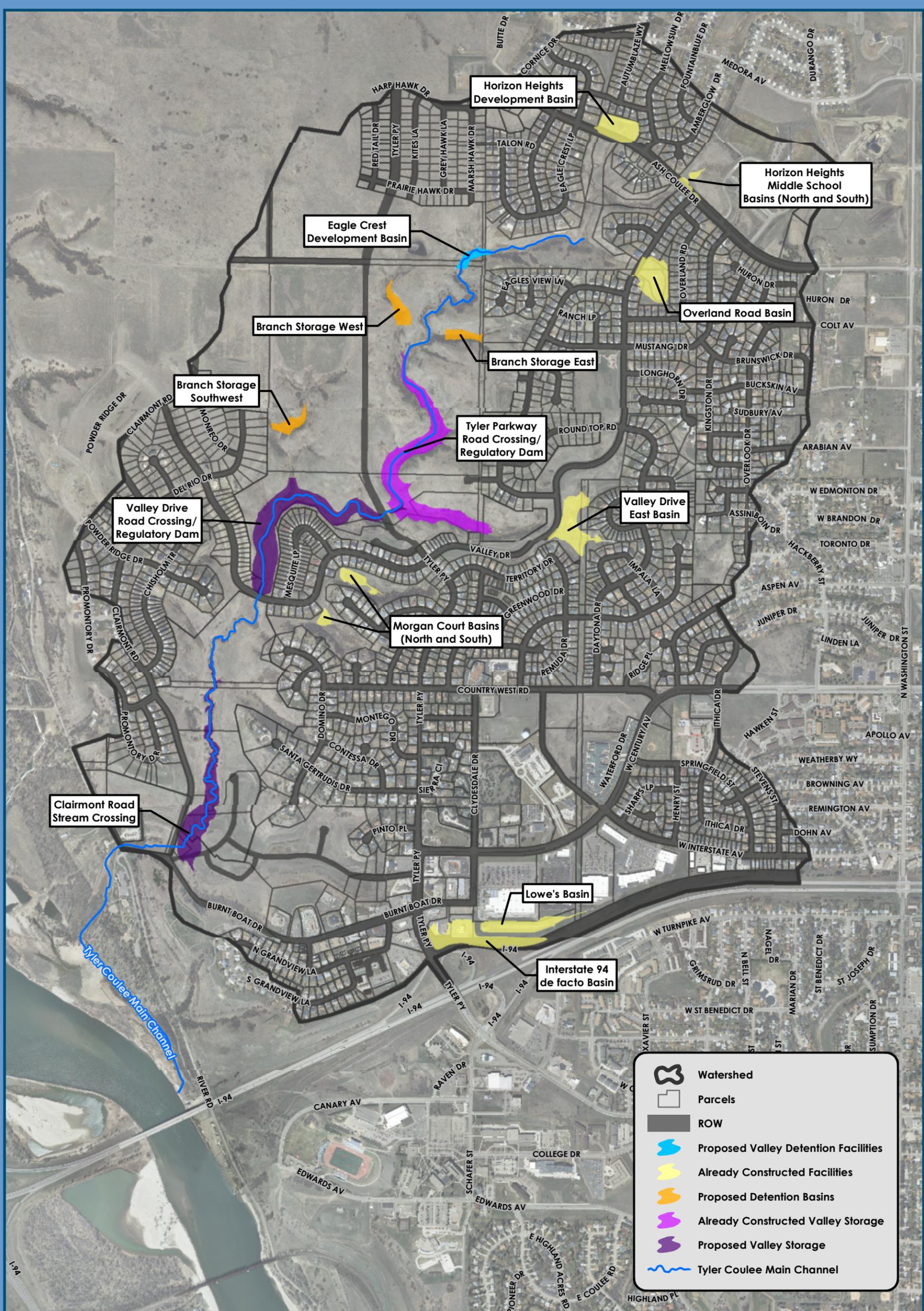
 Full Build-Out Watershed  
 Full Build-Out Subwatersheds  
 10-Foot Contours

Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

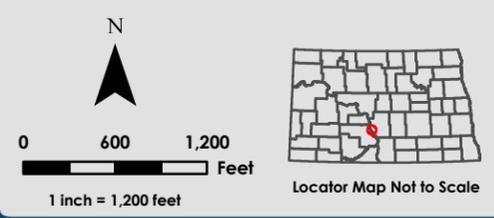
  
  
 1 inch = 1,200 feet  
  
 Locator Map Not to Scale

**Figure 3-**  
**Full Build-Out Subwatersheds**  
**Tyler Coulee Stormwater Ponds**  
**City of Bismarck | Burleigh County, ND**

  
 Advanced Engineering and  
 Environmental Services, Inc.

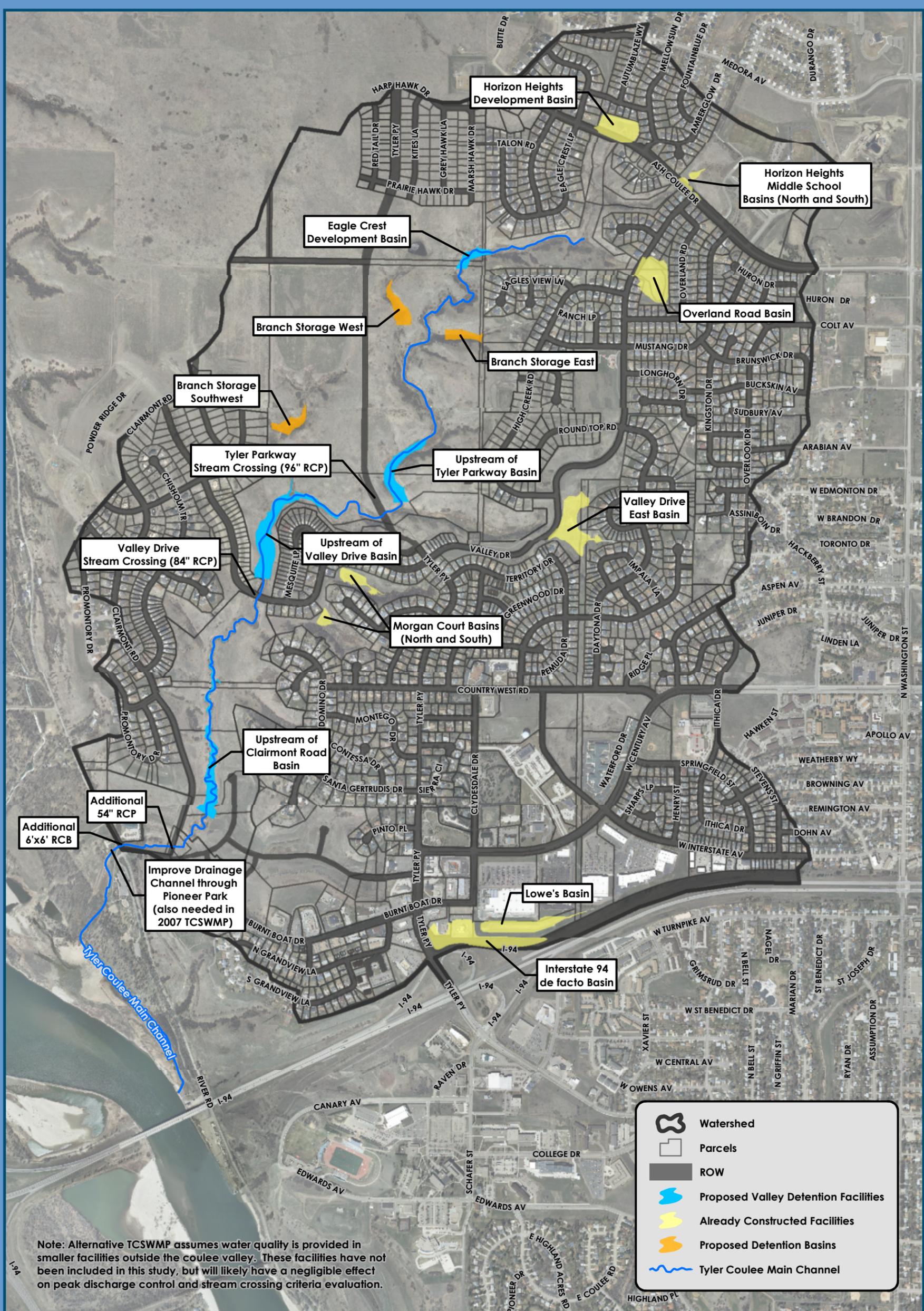


Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.



**Figure 4-**  
**Original TCSWMP Improvements**  
**Tyler Coulee Stormwater Ponds**  
**City of Bismarck | Burleigh County, ND**





Note: Alternative TCSWMP assumes water quality is provided in smaller facilities outside the coulee valley. These facilities have not been included in this study, but will likely have a negligible effect on peak discharge control and stream crossing criteria evaluation.

	Watershed
	Parcels
	ROW
	Proposed Valley Detention Facilities
	Already Constructed Facilities
	Proposed Detention Basins
	Tyler Coulee Main Channel

0 600 1,200 Feet  
1 inch = 1,200 feet

N

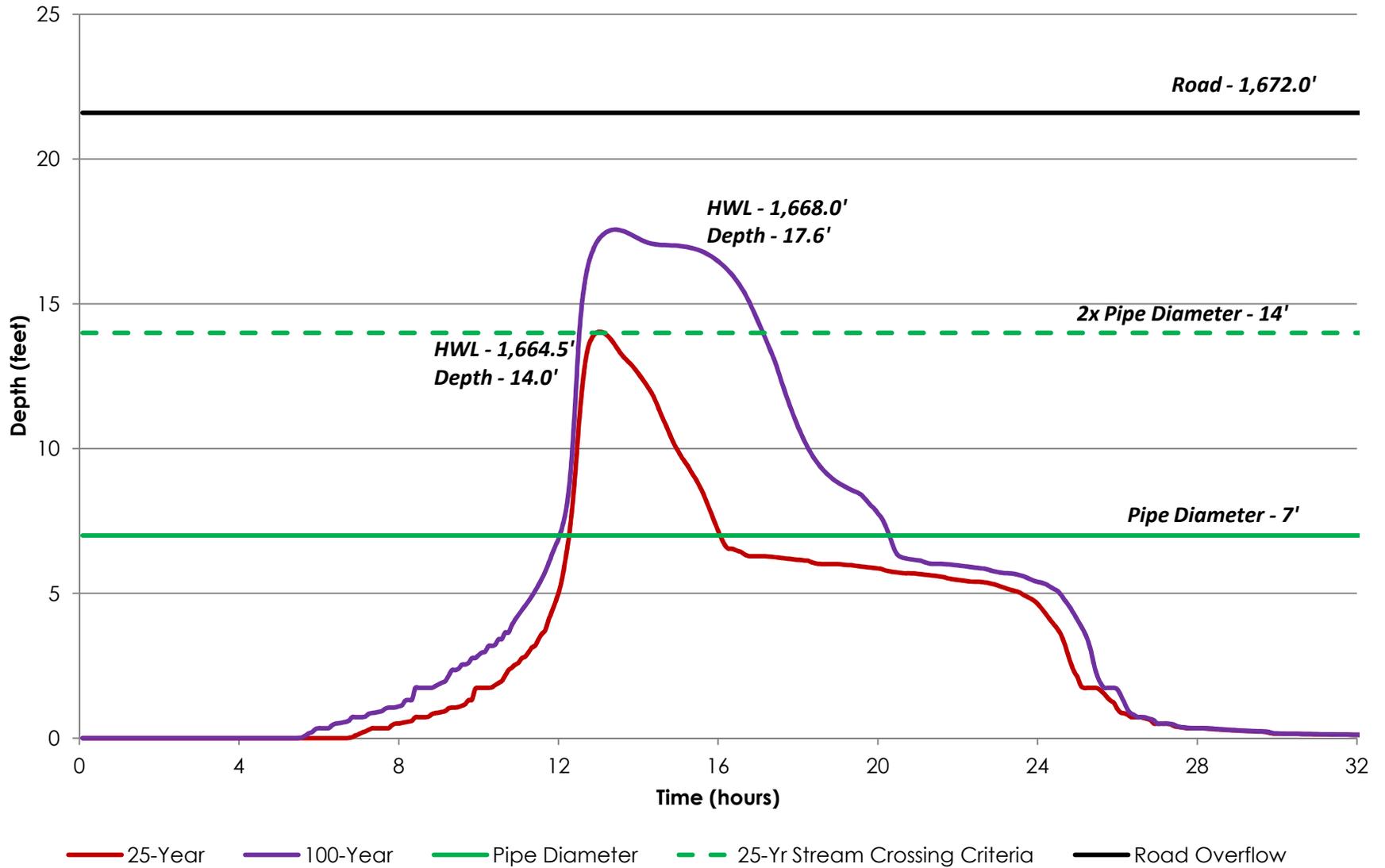
Locator Map Not to Scale

**Figure 5-**  
**Alternative TCSWMP Improvements**  
**Tyler Coulee Stormwater Ponds**  
**City of Bismarck | Burleigh County, ND**

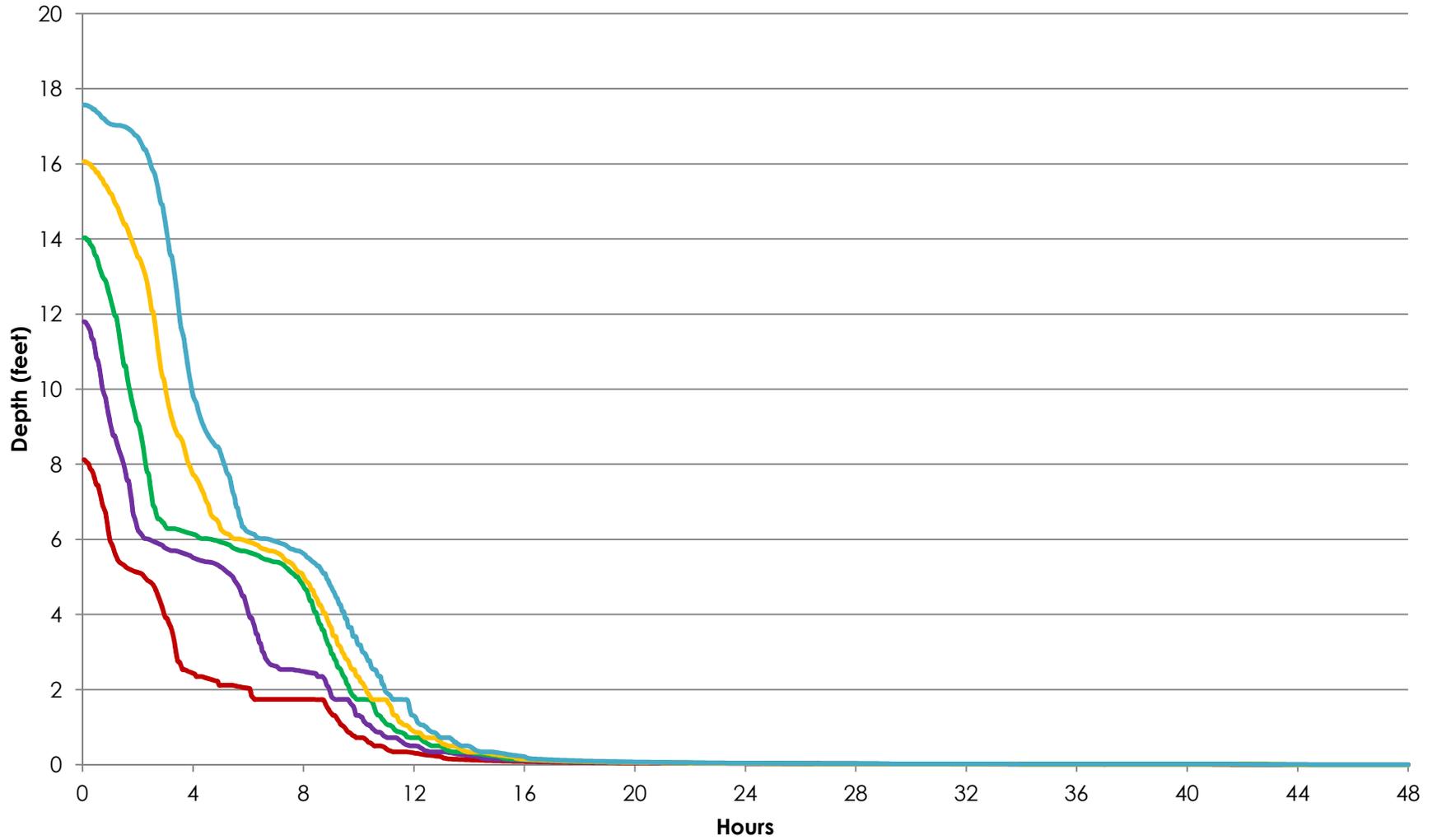


**CHARTS**

**Chart 1**  
**Clairmont Road - TCSWMP**  
**25- and 100-Year, 24-Hour Depth Hydrographs**

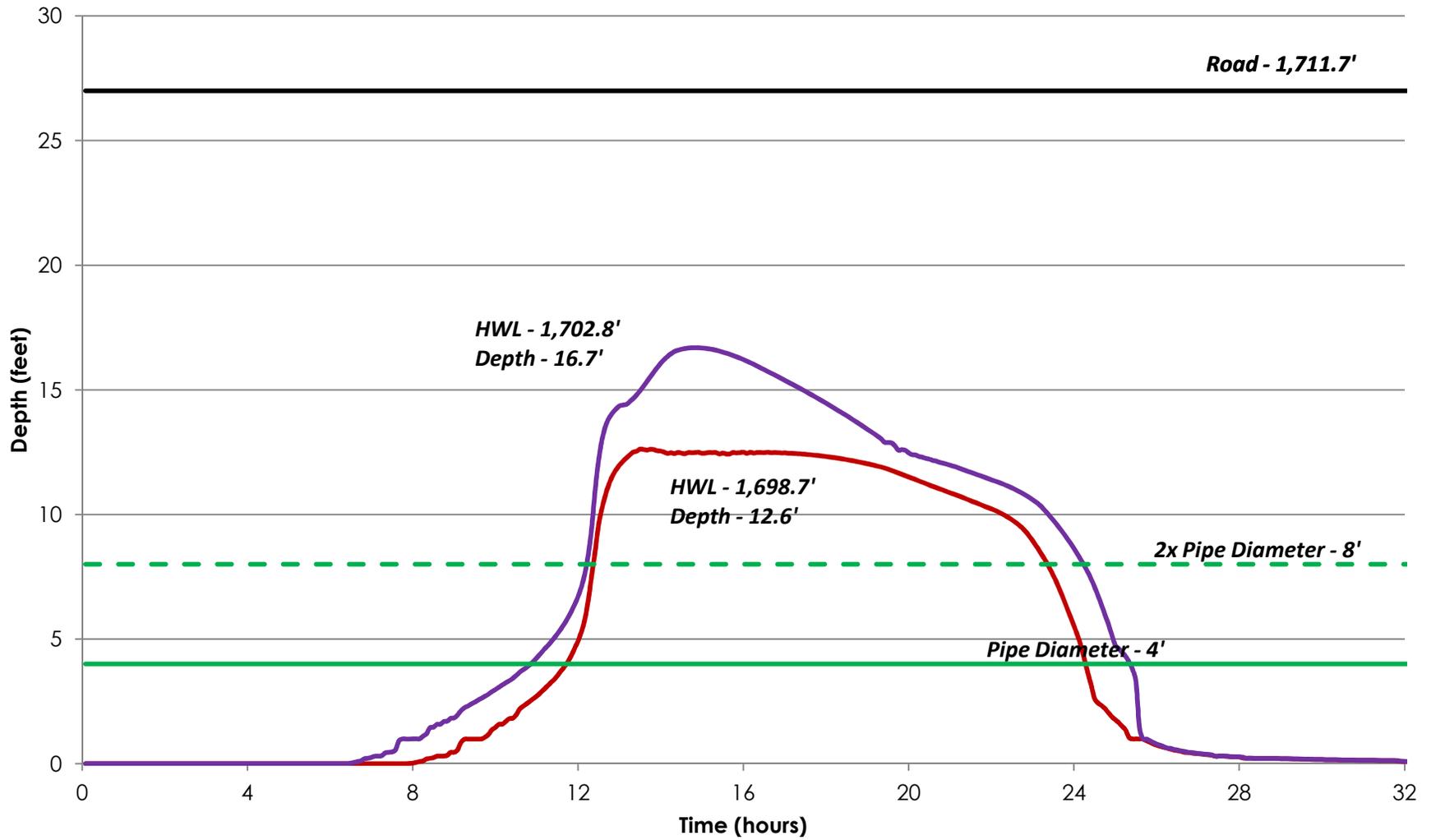


**Chart 2**  
**Clairmont Road Stage Duration (TCSWMP)**



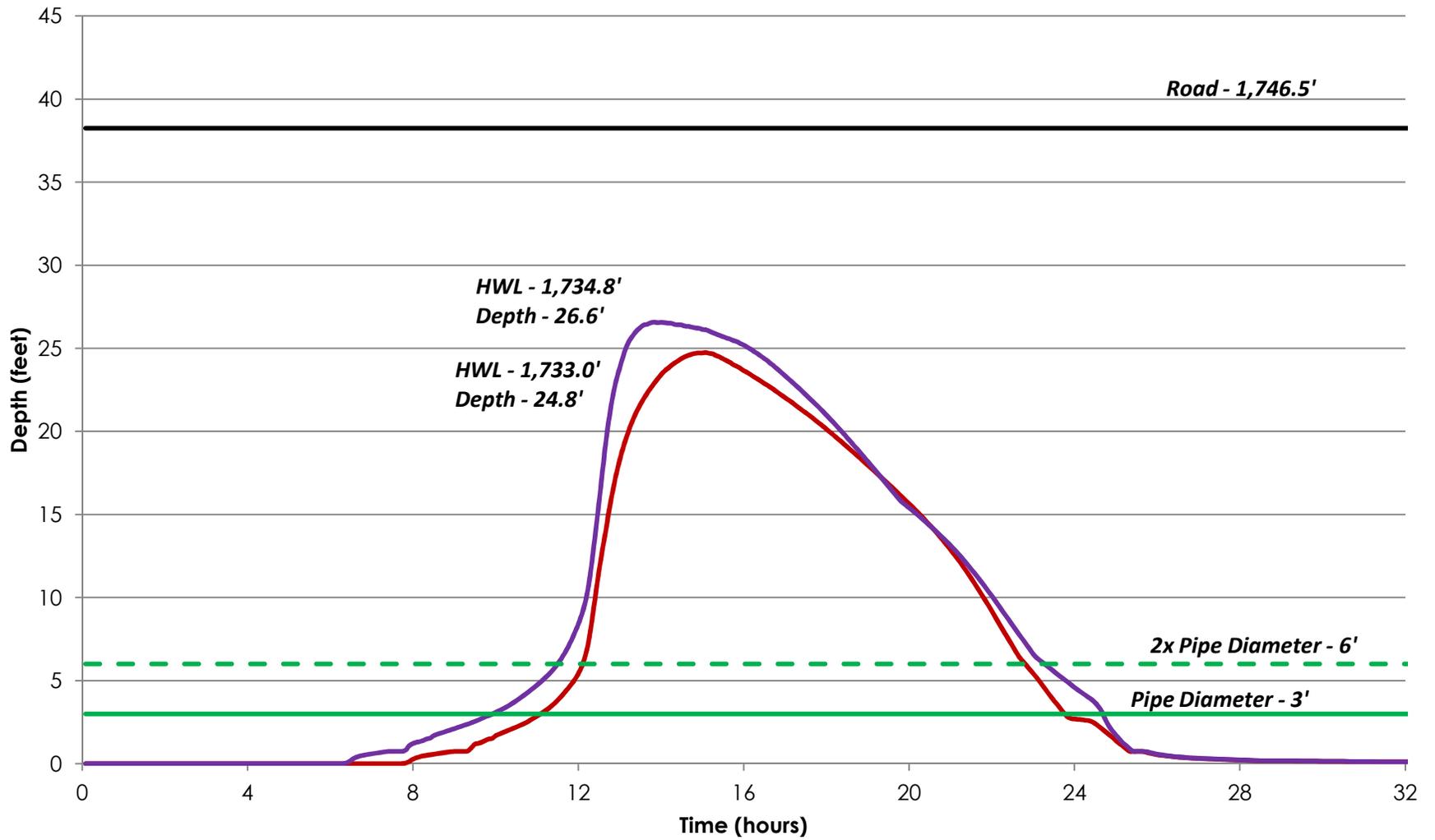
— 2-Year — 10-Year — 25-Year — 50-Year — 100-Year

**Chart 3**  
**Valley Drive - TCSWMP**  
**25- and 100-Year, 24-Hour Depth Hydrographs**



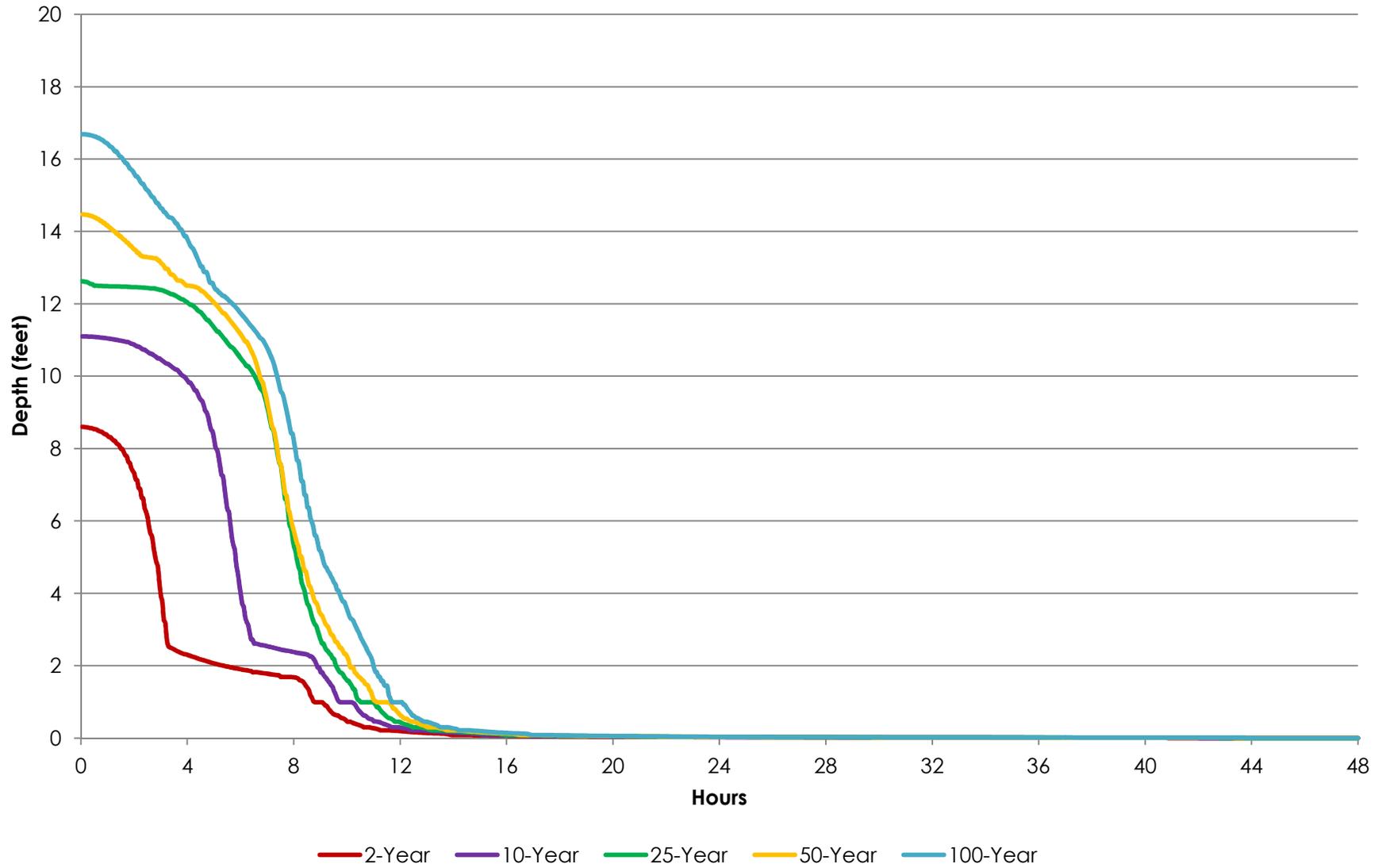
— 25-Year    
 — 100-Year    
 — Pipe Diameter    
 - - - 25-Yr Stream Crossing Criteria    
 — Road Overflow

**Chart 4**  
**Tyler Parkway - TCSWMP**  
**25- and 100-Year, 24-Hour Depth Hydrographs**

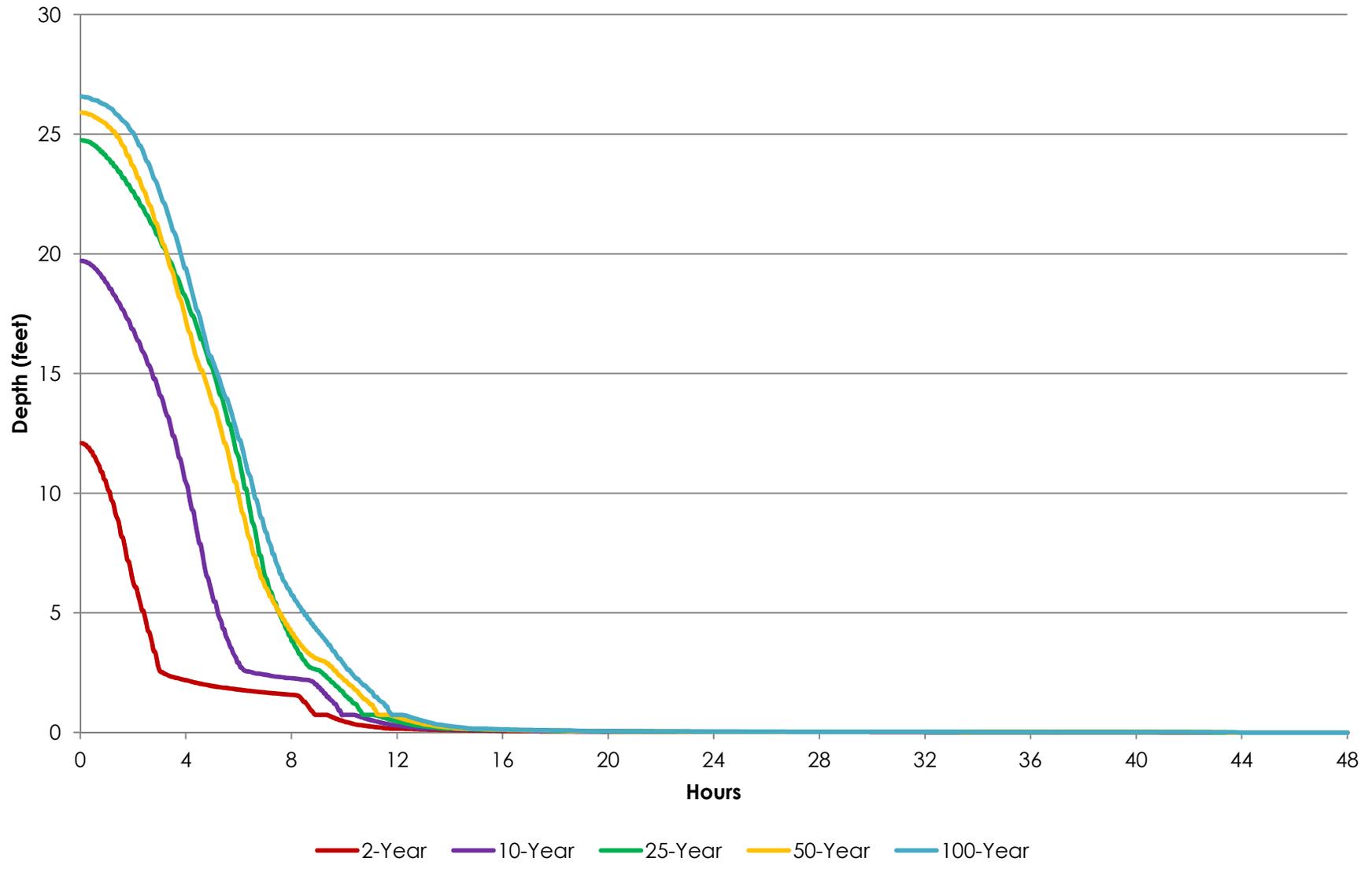


— 25-Year    
 — 100-Year    
 — Pipe Diameter    
 - - - 25-Yr Stream Crossing Criteria    
 — Road Overflow

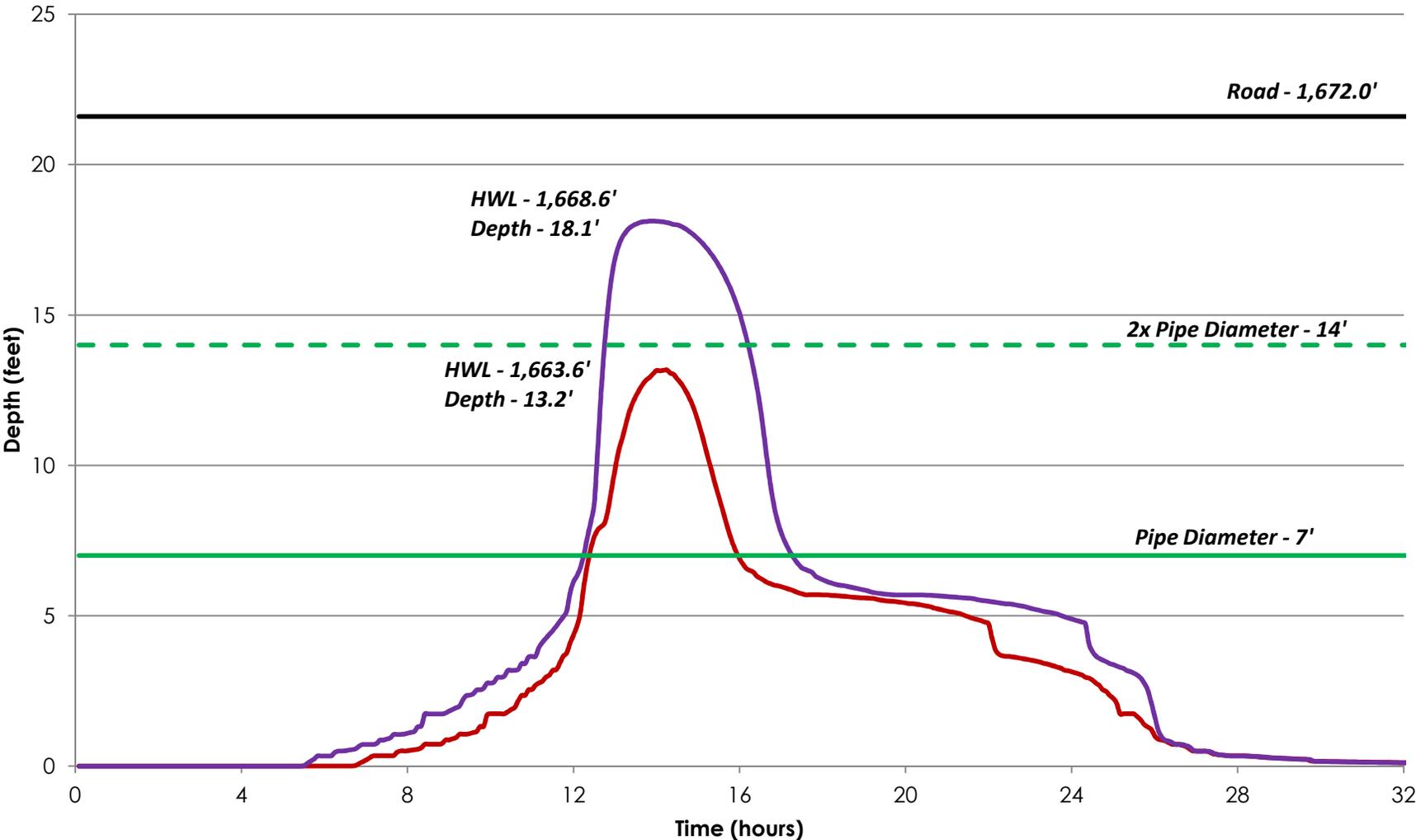
**Chart 5**  
**Valley Drive Stage Duration (TCSWMP)**



**Chart 6**  
**Tyler Parkway Stage Duration (TCSWMP)**

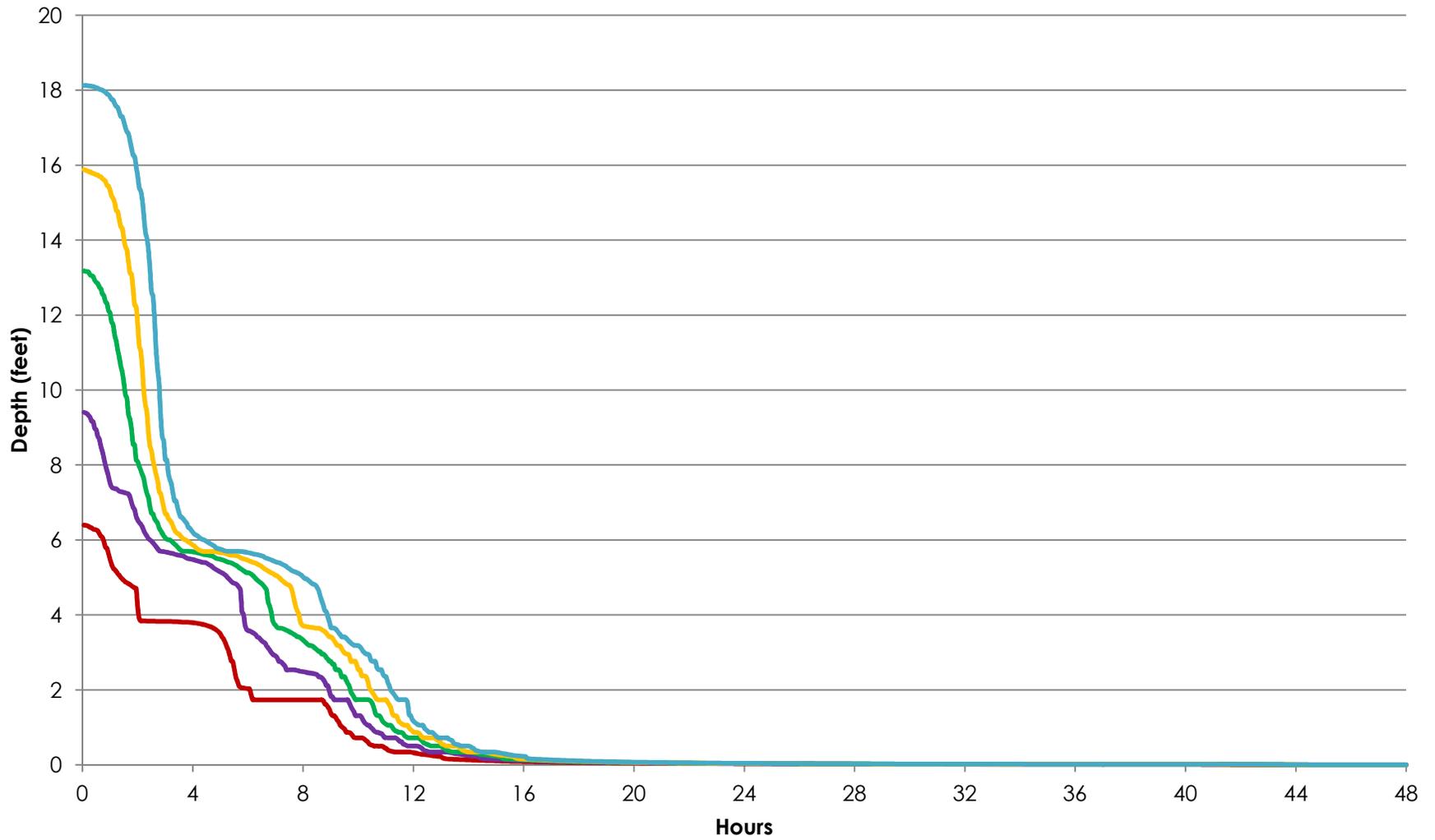


**Chart 7**  
**Clairmont Road - Alternative Plan**  
**25- and 100-Year, 24-Hour Depth Hydrographs**



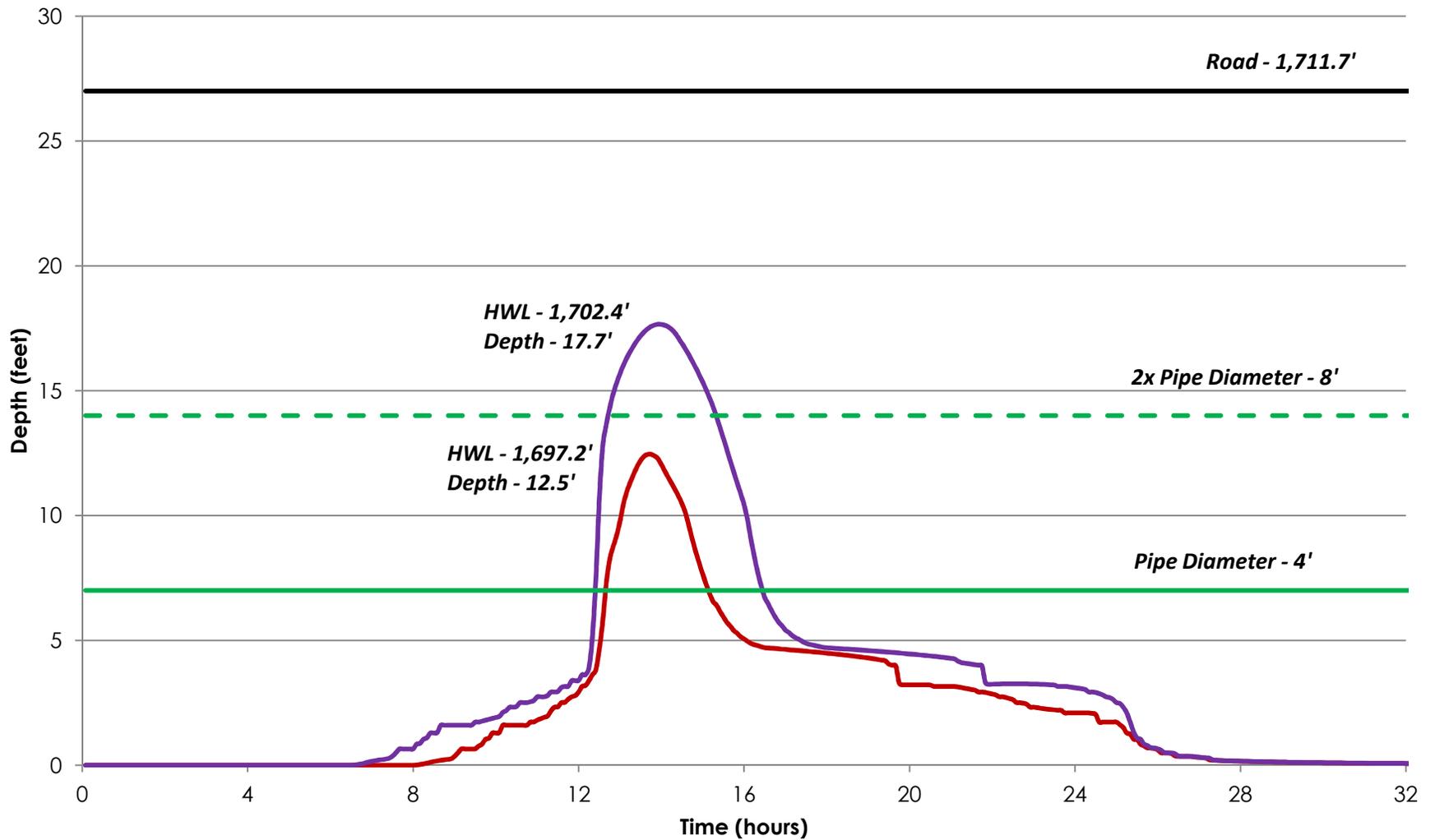
— 25-Year    
 — 100-Year    
 — Pipe Diameter    
 - - - 25-Yr Stream Crossing Criteria    
 — Road Overflow

**Chart 8**  
**Clairmont Road Stage Duration (Alternative)**



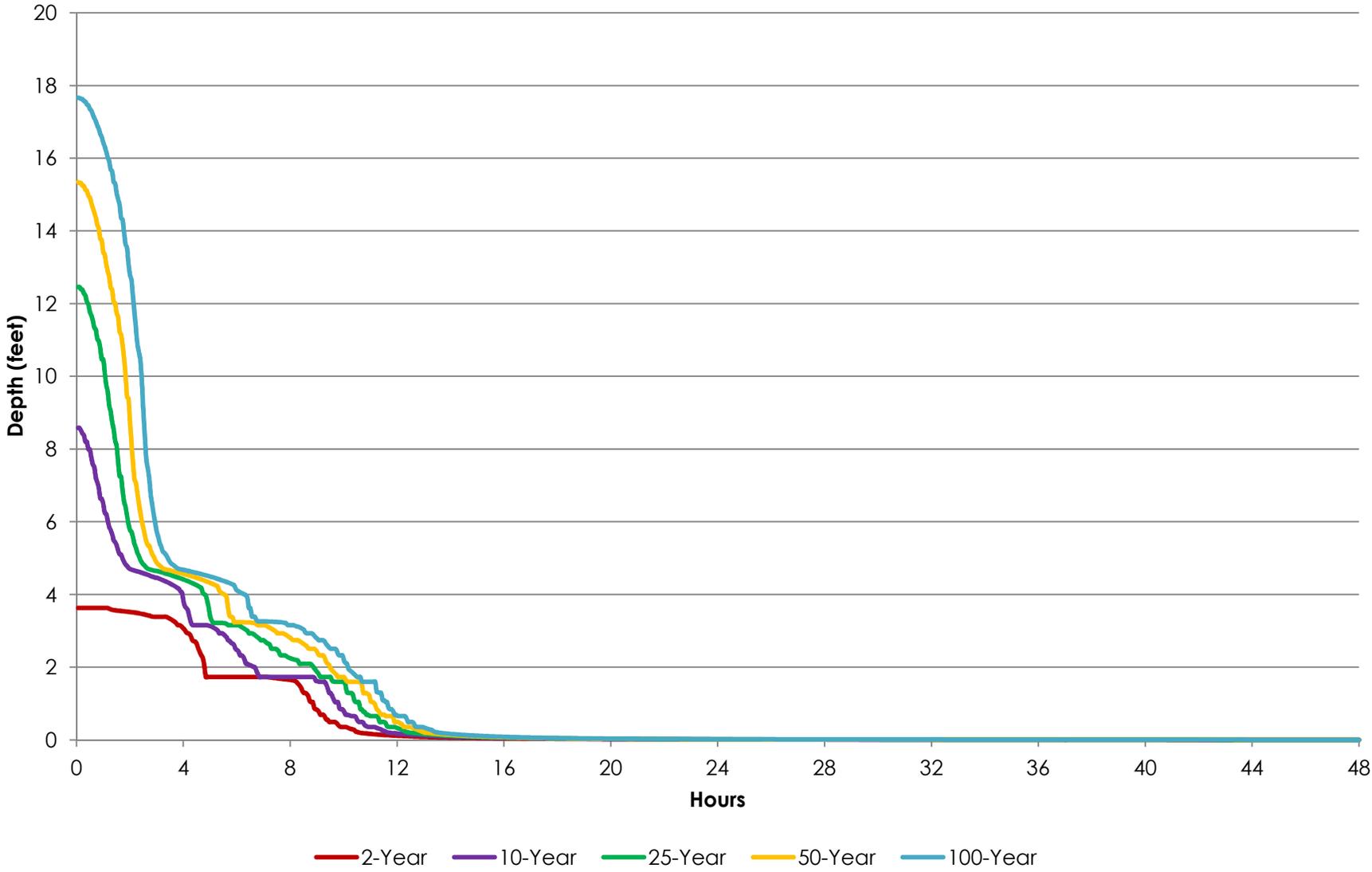
— 2-Year — 10-Year — 25-Year — 50-Year — 100-Year

**Chart 9**  
**Valley Drive - Alternative Plan**  
**25- and 100-Year, 24-Hour Depth Hydrographs**

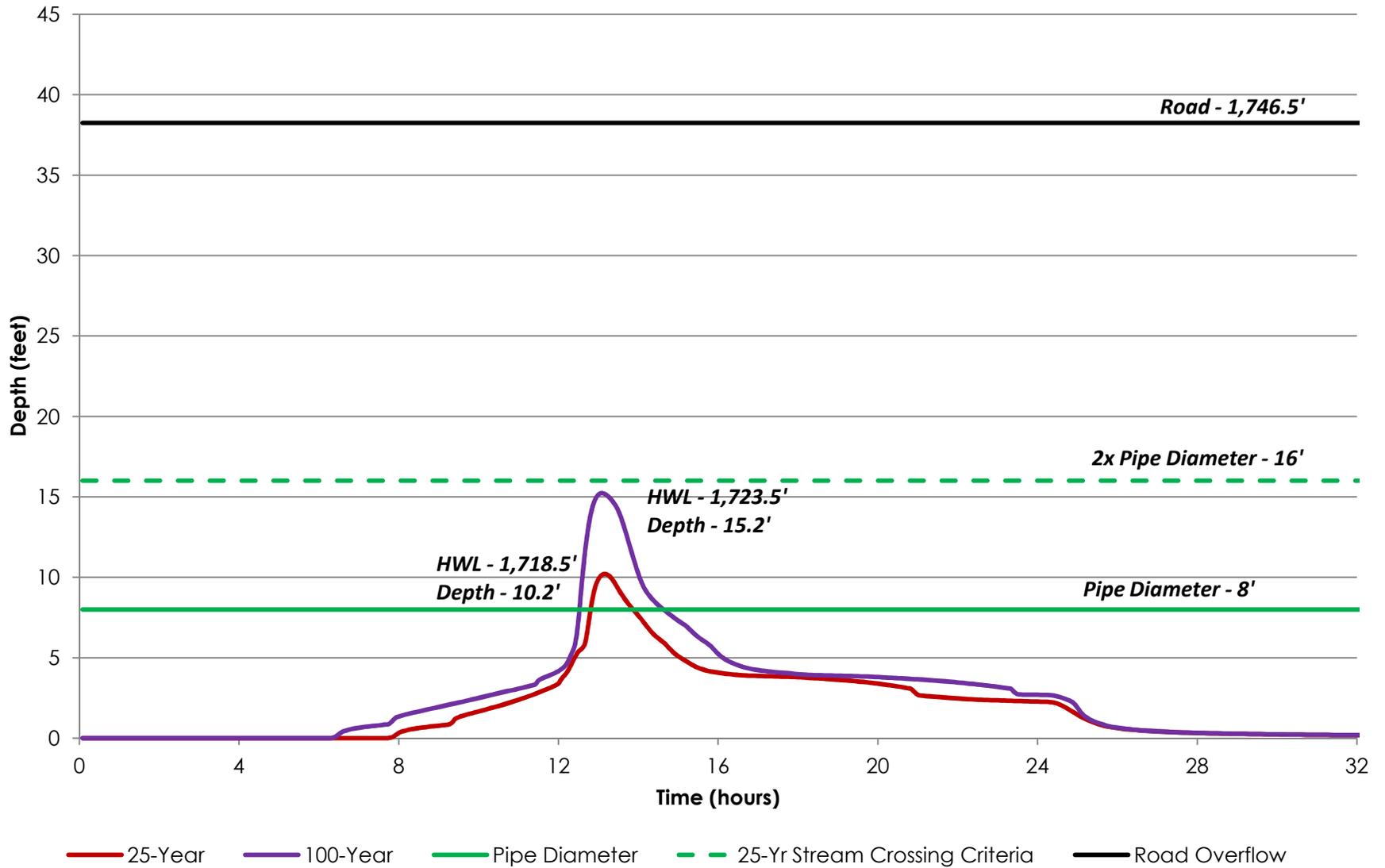


— 25-Year    — 100-Year    — Pipe Diameter    - - - 25-Yr Stream Crossing Criteria    — Road Overflow

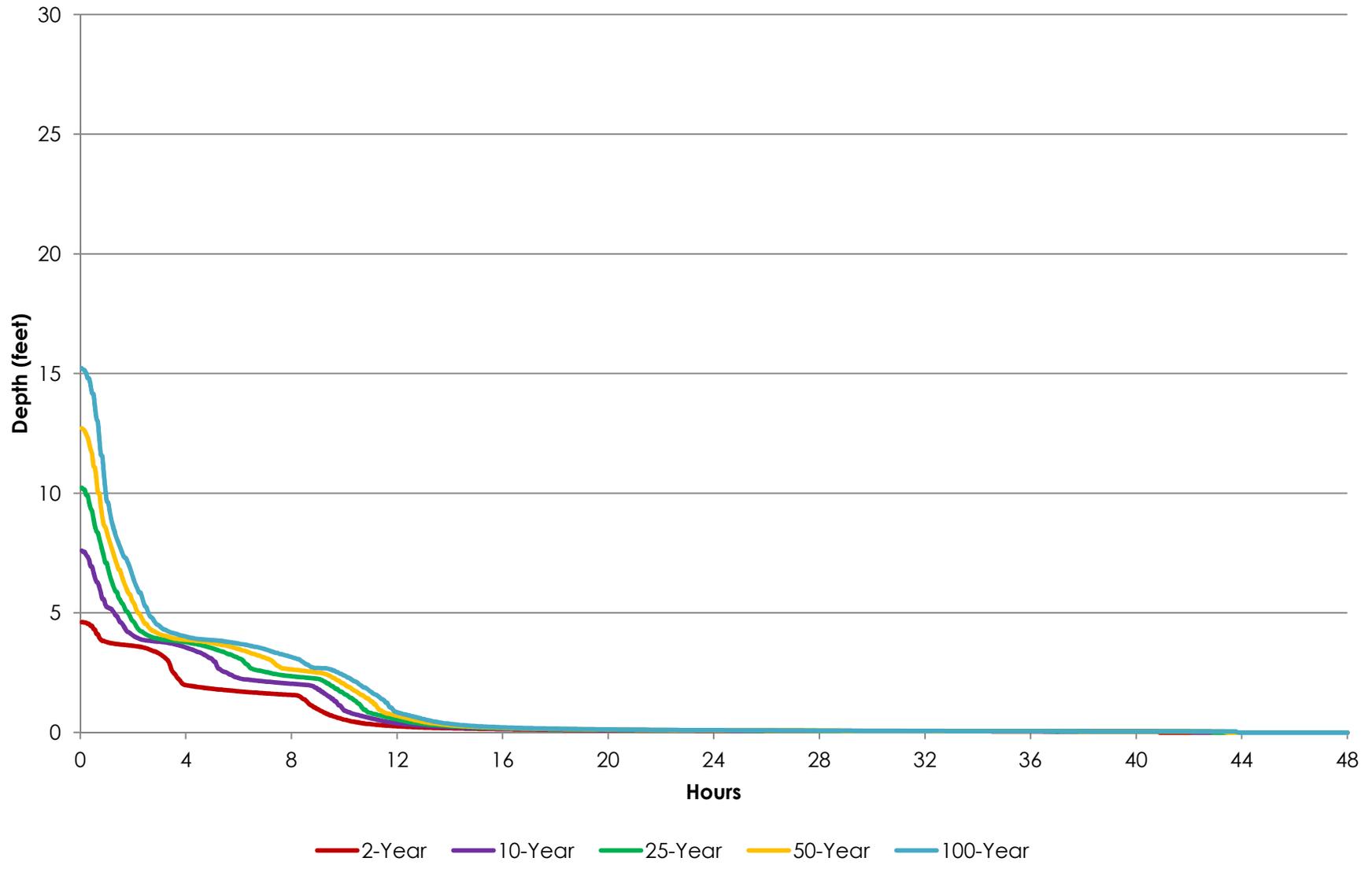
**Chart 10**  
**Valley Drive Stage Duration (Alternative)**



**Chart 11**  
**Tyler Parkway - Alternative Plan**  
**25- and 100-Year, 24-Hour Depth Hydrographs**



**Chart 12**  
**Tyler Parkway Stage Duration (Alternative)**



**ADDITIONAL TABLES**

**Table 2: Summary of Existing and Planned Tyler Coulee Storage Facilities – Original and Alternative TCSWMP**

Basin	Structure	TCSWMP	Alternate
Horizon Heights Middle School (North)	Low Flow Culvert (in)	36	36
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	36	36
	Embankment Height (ft)	7	7
	Maximum Storage Volume (ac-ft)	0.67	0.67

Basin	Structure	TCSWMP	Alternate
Branch Storage West	Low Flow Culvert (in)	N/A	N/A
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	24	24
	Embankment Height (ft)	28	28
	Maximum Storage Volume (ac-ft)	11.7	11.7

Basin	Structure	TCSWMP	Alternate
Morgan Court North	Low Flow Culvert (in)	18	18
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	18	18
	Embankment Height (ft)	9	9
	Maximum Storage Volume (ac-ft)	3.5	3.5

Basin	Structure	TCSWMP	Alternate
Clairmont Road Crossing	Low Flow Culvert (in)	84	84
	Secondary Structure Height (ft)	N/A	5
	Secondary Structure Size	N/A	54" RCP
	High Flow Culvert Size (in)	84	84
	Embankment Height (ft)	15.5	15.5
	Maximum Storage Volume (ac-ft)	64.4*	39.5**

\*Max 100-year storage is 32.7 ac-ft  
 \*\*Max 100-year storage is 11 ac-ft

Basin	Structure	TCSWMP	Alternate
Horizon Heights Middle School (South)	Low Flow Culvert (in)	36	36
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	36	36
	Embankment Height (ft)	12	12
	Maximum Storage Volume (ac-ft)	0.83	0.83

Basin	Structure	TCSWMP	Alternate
Valley Drive East	Low Flow Culvert (in)	36	36
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	36	36
	Embankment Height (ft)	15.5	15.5
	Maximum Storage Volume (ac-ft)*	28	28

\*100-Year Maximum Storage is approximately 11.9 ac-ft

Basin	Structure	TCSWMP	Alternate
Morgan Court South	Low Flow Culvert (in)	18	18
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	18	18
	Embankment Height (ft)	7	7
	Maximum Storage Volume (ac-ft)	1.1	1.1

Basin	Structure	TCSWMP	Alternate
Lowe's Detention Basin	Low Flow Culvert (in)	36	36
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	36	36
	Embankment Height (ft)	12	12
	Maximum Storage Volume (ac-ft)	14.8	14.8

Basin	Structure	TCSWMP	Alternate
Horizon Heights Development	Low Flow Culvert (in)	24	24
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	24	24
	Embankment Height (ft)	14.5	14.5
	Maximum Storage Volume (ac-ft)	17.3	17.3

Basin	Structure	TCSWMP	Alternate
Branch Storage Southwest	Low Flow Culvert (in)	24	24
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	24	24
	Embankment Height (ft)	17.15	17.15
	Maximum Storage Volume (ac-ft)	2.2	2.2

Basin	Structure	TCSWMP	Alternate
New Upstream Valley Detention	Low Flow Culvert (in)	N/A	36
	Secondary Structure Height (ft)	N/A	10
	Secondary Structure Size	N/A	12x8 Box
	High Flow Culvert Size (in)	N/A	8x6 Box
	Embankment Height (ft)	N/A	12.7
	Maximum Storage Volume (ac-ft)	N/A	24.9

Basin	Structure	TCSWMP	Alternate
Overland Road	Low Flow Culvert (in)	24	24
	Secondary Structure Height (ft)	11.3	11.3
	Secondary Structure Size	72" RCP	72" RCP
	High Flow Culvert Size (in)	36	36
	Embankment Height (ft)	28	28
	Maximum Storage Volume (ac-ft)*	40	40

Basin	Structure	TCSWMP	Alternate
New Upstream Tyler Detention	Low Flow Culvert (in)	N/A	24
	Secondary Structure Height (ft)	N/A	16.1
	Secondary Structure Size	N/A	14x8 Box
	High Flow Culvert Size (in)	N/A	84
	Embankment Height (ft)	N/A	19
	Maximum Storage Volume (ac-ft)	N/A	24.9

Basin	Structure	TCSWMP	Alternate
Valley Drive Road Crossing	Low Flow Culvert (in)	48	84
	Secondary Structure Height (ft)	15.78	N/A
	Secondary Structure Size*	20x16 Box	N/A
	High Flow Culvert Size (in)	12x8 Box	84
	Embankment Height (ft)**	25.28	27
	Maximum Storage Volume (ac-ft)	~160***	~135****

\*Only 20' sides effective (40' effective length)  
 \*\*Crest Elevation is Same - Higher U/S invert in TCSWMP  
 \*\*\*Max 100-year storage is 54.8 ac-ft  
 \*\*\*\*Max 100-year storage is 26.7 ac-ft

Basin	Structure	TCSWMP	Alternate
Eagle Crest Development	Low Flow Culvert (in)	48	24
	Secondary Structure Height (ft)	N/A	12
	Secondary Structure Size	N/A	8x4 Box
	High Flow Culvert Size (in)	48	60
	Embankment Height (ft)	12	16
	Maximum Storage Volume (ac-ft)	3.5	7.1

Basin	Structure	TCSWMP	Alternate
Tyler Road Crossing	Low Flow Culvert (in)	36	96
	Secondary Structure Height (ft)	24.59	N/A
	Secondary Structure Size	15x12 Box*	N/A
	High Flow Culvert Size (in)	8x6 Box	96
	Embankment Height (ft)	38.25	38.25
	Maximum Storage Volume (ac-ft)	193**	168***

\*Only 15' sides effective (30' effective length)  
 \*\*Max 100-year storage is 75.2 ac-ft  
 \*\*\*Max 100-year storage is ~10 ac-ft

Basin	Structure	TCSWMP	Alternate
New Upstream Clairmont Detention	Low Flow Culvert (in)	N/A	36
	Secondary Structure Height (ft)	N/A	14.9
	Secondary Structure Size	N/A	14x8 Box
	High Flow Culvert Size (in)	N/A	8x6 Box
	Embankment Height (ft)	N/A	15.5
	Maximum Storage Volume (ac-ft)	N/A	24.9

Basin	Structure	TCSWMP	Alternate
Branch Storage East	Low Flow Culvert (in)	N/A	N/A
	Secondary Structure Height (ft)	N/A	N/A
	Secondary Structure Size	N/A	N/A
	High Flow Culvert Size (in)	24	24
	Embankment Height (ft)	12	12
	Maximum Storage Volume (ac-ft)	1.8	1.8

Basin	Structure	TCSWMP	Alternate
Interstate 94 "De Facto" Storage	Low Flow Culvert (in)	60	60
	Secondary Structure Height (ft)*	3	3
	Secondary Structure Size*	24" RCP	24" RCP
	High Flow Culvert Size (in)	84	84
	Embankment Height (ft)*	7.2	7.2
	Maximum Storage Volume (ac-ft)	13.6	13.6

\*Flows south away from Tyler Coulee

Technical Memorandum

Re: City of Bismarck Valley Drive and Tyler Parkway – Revised Concept Design

February 19, 2015

**Table 3: Hydraulic Summary for Clairmont Road, Valley Drive, and Tyler Parkway – Original TCSWMP**

2007 TCSWMP																					
	Clairmont							Valley							Tyler						
Recurrence Interval	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)
2-Year	1,658.53	1,648.44	10.09	5.22	413	357	-13.6%	1,694.62	1,683.65	10.97	4.85	199	154	-22.6%	1,720.31	1,709.30	11.00	1.95	302	136	-55.0%
10-Year	1,662.21	1,648.96	13.25	5.22	738	517	-29.9%	1,697.12	1,683.85	13.27	4.85	335	183	-45.4%	1,727.91	1,709.37	18.54	1.95	464	149	-67.9%
25-Year	1,664.45	1,649.17	15.28	5.22	990	592	-40.2%	1,698.66	1,684.30	14.36	4.85	503	267	-46.9%	1,732.97	1,709.47	23.50	1.95	651	174	-73.3%
50-Year	1,666.47	1,649.33	17.15	5.22	1,218	653	-46.4%	1,700.49	1,684.61	15.88	4.85	659	332	-49.6%	1,734.13	1,710.00	24.13	1.95	884	346	-60.9%
100-Year	1,667.98	1,649.43	18.55	5.22	1,446	694	-52.0%	1,702.71	1,685.11	17.60	4.85	874	452	-48.3%	1,734.80	1,710.22	24.59	1.95	1,120	446	-60.2%

**Table 4: Hydraulic Summary for Clairmont Road, Valley Drive, and Tyler Parkway – Alternative TCSWMP**

Alternate Plan																					
	Clairmont							Valley							Tyler						
Recurrence Interval	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)	Upstream Max HGL	Downstream Max HGL	Head Differential	Invert Differential	Q in	Q out	Qdiff (%)
2-Year	1,656.81	1,648.15	8.66	5.22	277	277	0.0%	1,688.29	1,681.60	6.69	4.85	115	115	0.0%	1,712.82	1,711.05	1.77	1.95	139	139	0.0%
10-Year	1,659.82	1,648.96	10.86	5.22	521	519	-0.4%	1,693.25	1,683.14	10.11	4.85	385	383	-0.5%	1,715.81	1,711.62	4.18	1.95	375	352	-6.1%
25-Year	1,663.62	1,649.56	14.06	5.22	756	748	-1.1%	1,697.13	1,683.78	13.35	4.85	544	541	-0.6%	1,718.44	1,711.98	6.46	1.95	593	551	-7.1%
50-Year	1,666.29	1,649.85	16.44	5.22	902	872	-3.3%	1,700.01	1,684.12	15.89	4.85	635	632	-0.5%	1,720.92	1,712.14	8.78	1.95	734	655	-10.8%
100-Year	1,668.54	1,650.05	18.49	5.22	1,094	963	-12.0%	1,702.33	1,684.32	18.01	4.85	700	697	-0.4%	1,723.43	1,712.28	11.16	1.95	911	749	-17.8%